

# Echinoderms of the Rockall Trough and adjacent areas

## 2. Echinoidea and Holothurioidea

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### Introduction

Eighteen species of echinoid and thirty-three species of holothurian are identified from a sampling programme conducted by the Scottish Marine Biological Association in the deep-sea areas lying to the west of Scotland and Ireland. Of these only one echinoid (*Aeropsis rostrata*) and 11 holothurians are unrecorded previously for the seas around the British Isles; these include two undescribed species of the holothurian order Apodida. The zoogeographical distribution and bathymetric range of each species are summarised as far as was previously known giving any range extension provided by the present records. Details are also provided on the biology of many species including their mode of reproduction. For certain echinoid species, the records demonstrate a broader bathymetric distribution for post larval stages than for the adult population. No such trend was evident amongst the holothurians. Holothurian species diversity was low on the west side of the Rockall Trough, an area where there is considerable current activity. This is in contrast to the pattern found for the Asteroidea and Ophiuroidea, which included several suspension-feeding species. There are few deep-sea suspension-feeding holothurian species, but apart from this the apparent scarcity of holothurians may be more appropriately attributed to unstable sedimentary conditions or possibly sampling bias.

The descriptive account of the echinoderm fauna in the samples, taken by the Scottish Marine Biological Association (SMBA) in the Rockall Trough area, is divided into two parts. The first part (Gage, Pearson, Clark, Paterson & Tyler, 1983) provides an introduction to the SMBA sampling programme, station data, records of the classes Crinoidea, Asteroidea and Ophiuroidea, bathymetric and geographic distributions in relation to previous records and details of the biology of many species. The second part provides similar information for the two remaining classes, the Echinoidea and Holothurioidea, the format following that of part 1.

### List of Species

Class Echinoidea

Order Cidaroida

Family Cidaridae

*Cidaris cidaris* (Linnaeus)

*Poriodidaris purpurata* (Wyville Thomson)

Order Echinothurioida

Family Echinothuriidae

*Araeosoma fenestratum* (Wyville Thomson)

*Calveriosoma hystrix* (Wyville Thomson)

*Hygrosoma petersii* (A. Agassiz)

### Station List

Only details of bottom sampling stations worked, yielding records of echinoids and holothurians, that are not listed by Gage *et al.* (1983) are given below.

Station No.	Date	Position (at mid-point of track on bottom if applicable)	Depth (m)
<b>Benthic stations</b>			
ES 110	22 Oct. 1976	54°41'N, 12°14'W	2886
ES 122	29 Jan. 1977	54°31'N, 12°31'W	2951
AT 130	7 April 1977	54°46'N, 12°19'W	c. 2900
ES T36	21 Feb. 1978	54°29'N, 12°18'W	2900
SBC 174	27 May 1980	54°44'N, 12°18'W	2885
SBC 188	15 Aug. 1981	54°41'N, 12°10'W	2876
AT 193	18 Aug. 1981	57°28'N, 11°08'W	616
AT 201	9 May 1982	57°22'N, 10°30'W	2180
ES 202	10 May 1982	57°22'N, 10°30'W	2180
ES 204	12 May 1982	54°40'N, 12°20'W	2904
SBC 205	31 July 1982	54°40'N, 12°15'W	2906
ES 206	1 Aug. 1982	54°40'N, 12°16'W	2900
ES 207	1 Aug. 1982	54°40'N, 12°11'W	2906
SBC 209	2 Aug. 1982	56°41'N, 09°00'W	416
SBC 210	2 Aug. 1982	56°40'N, 09°00'W	401
SBC 211	2 Aug. 1982	56°41'N, 09°00'W	402
SBC 212	2 Aug. 1982	56°43'N, 09°00'W	601
SBC 213	2 Aug. 1982	56°45'N, 09°06'W	841
SBC 214	2 Aug. 1982	56°45'N, 09°11'W	1062
SBC 215	3 Aug. 1982	57°02'N, 09°47'W	2001
SBC 216	3 Aug. 1982	57°19'N, 10°23'W	2200
ES 218	3 Aug. 1982	57°22'N, 10°24'W	2175
AT 219	3 Aug. 1982	57°25'N, 10°28'W	1991
SBC 220	4 Aug. 1982	59°05'N, 08°51'W	1608
AT 221	5 Aug. 1982	59°05'N, 08°55'W	1605
SBC 222	5 Aug. 1982	59°43'N, 07°10'W	1101
AT 223	5 Aug. 1982	59°41'N, 07°09'W	1075
SBC 224	6 Aug. 1982	60°10'N, 08°24'W	903
SBC 225	6 Aug. 1982	60°16'N, 06°56'W	1145
AT 226	6 Aug. 1982	60°16'N, 06°53'W	1118
SBC 227	6 Aug. 1982	61°00'N, 07°30'W	862
AT 228	10 Aug. 1982	57°01'N, 09°51'W	2026
AT 229	11 Aug. 1982	56°43'N, 09°30'W	1587
AT 230	11 Aug. 1982	56°44'N, 09°12'W	1210
<b>Fishing station</b>			
OTSB 51301	15 Feb. 1982	54°46'N, 12°14'W (starting position)	mean 2925

- Sperosoma grimaldii* Koehler  
 Family Phormosomatidae  
*Phormosoma placenta* Wyville Thomson
- Order Echinoida  
 Family Echinidae  
*Echinus acutus* Lamarck  
*Echinus affinis* Mortensen  
*Echinus alexandri* Danielssen & Koren  
*Echinus elegans* Düben & Koren  
*Echinus esculentus* Linnaeus
- Order Spatangoida  
 Family Aeropsidae  
*Aeropsis rostrata* (Wyville Thomson)  
 Family Hemiasteridae  
*Hemiaster expergitus* Lovén  
 Family Spatangidae  
*Brissopsis* sp.  
*Spatangus raschi* Lovén
- Order Pourtalesioida  
 Family Pourtalesiidae  
*Pourtalesia jeffreysi* Wyville Thomson  
*Pourtalesia miranda* A. Agassiz  
*Echinogira phiale* (Wyville Thomson)
- Class Holothurioidea  
 Order Dendrochirotida  
 Family Psolidae  
*Psolus pourtalesii* Théel  
*Psolus squamatus* (Koren)  
 Family Cucumariidae  
*Abyssocucumis abyssorum* (Théel)
- Order Dactylochirotida  
 Family Ypsilothuriidae  
*Ypsilothuria talismani talismani* E. Perrier  
*Ypsilothuria bitentaculata attenuata* R. Perrier  
*Echinocucumis hispida* (Barrett)
- Order Aspidochirotida  
 Family Synallactidae  
*Bathyplotes natans* (M. Sars)  
*Benthothuria funebris* R. Perrier  
*Paelopatides grisea* R. Perrier  
*Mesothuria cathedralis* Heding  
*Mesothuria lactea* (Théel)  
*Pseudostichopus villosus* Théel  
 Family Stichopodidae  
*Stichopus tremulus* (Gunnerus)
- Order Elasipodida  
 Family Deimatidae  
*Oneirophanta mutabilis mutabilis* Théel  
 Family Laetmogonidae  
*Benthogone rosea* Koehler  
*Laetmogone violacea* Théel  
 Family Psychropotidae  
*Benthoodytes lingua* R. Perrier  
*Psychropotes depressa* (Théel)  
*Psychropotes longicauda* Théel

## Family Elpidiidae

*Peniagone azorica* von Marenzeller*Peniagone diaphana* (Théel)*Kolga hyalina* Danielssen & Koren

## Order Apodida

## Family Synaptidae

*Labidoplax southwardorum* Gage*Labidoplax similimedia* Gage*Protankyra brychia* (Verrill)

## Family Myriotrochidae

*Myriotrochus bathybius* H. L. Clark*Myriotrochus giganteus* H. L. Clark*Myriotrochus* sp.*Prototrochus zenkevitchi* subsp.*Prototrochus* sp. aff. *P. minutus* (Östergren)

## Order Molpadiida

## Family Molpadiidae

*Cherbonniera utriculus* Sibuet*Molpadia blakei* (Théel)*Molpadia borealis* M. Sars

## Systematic Account

A chart showing the station localities for all records is given in Fig. 1. More detailed charts for the most abundant echinoid and holothurian species in the central part of the Rockall Trough are given in Figs 2 and 5, respectively.

The classification of the class Echinoidea is based on that of Jensen (1982) and Smith (1981), although for brevity omitting some higher stages of Jensen's classification. That for the six orders of the Holothurioidea follows Pawson & Fell (1965) for the Dendrochirotida and Dactylochirotida, Hansen (1975) for the Elasipodida, Deichmann (1930) for the Aspidochirotida (except that *Zygothuria* is treated as a synonym of *Mesothuria*), Deichmann (1940) for the Molpadiida, and Clark (1907) for the Apodida. The classifications for the Aspidochirotida and Molpadiida proposed by Heding (1931, 1935, 1940, 1942) have, in most cases, been rejected and are not used. References to the size of animals, if given, refer to maximum test diameter or length of echinoids while the maximum body length of holothurians does not include retractile parts, such as the tentacles, tube feet or papillae that sometimes are not visible in fixed material.

Although all co-authors have been involved in the preparation of the text, taxonomic responsibility is taken by M.J. and J.D.G. for the echinoids, by J.D.G. for the holothurian order Apodida, and by D.S.M.B. for all remaining holothurians. Material of all species referred to in the present account will be deposited with the British Museum (Natural History).

## Class ECHINOIDEA

## Order CIDAROIDA

## Family CIDARIDAE

*Cidaris cidaris* (Linnaeus, 1758)

See: Mortensen, 1903: 31–35, pl. 6, figs 6, 7, 8, pl. 8, figs 1, 3, 12, 14, 27, pl. 9, figs 3, 5, 7, 13–15, 20, 25, 27, pl. 11, figs 14, 26, 31 (as *Dorocidaris papillata*); 1927: 272–273, figs 149, 150(1, 2), 151, 152; 1928: 289–301, pl. 30, figs 3, 4, pl. 31, figs 1–10, pl. 67, fig. 5, pl. 72, figs 20–22.

SAMPLES. ES 23(1), AT 162(1), AT 193(1), AT 194(2), GT 7(3), GT 11(1), GT 12(1), GT 13(1), GT 14(1). [508–543 m to 934–1054 m]

DISTRIBUTION. Norwegian coast to the Cape Verde Islands and St Helena, also in the Mediterranean; 50–1800 m; on a variety of bottoms.

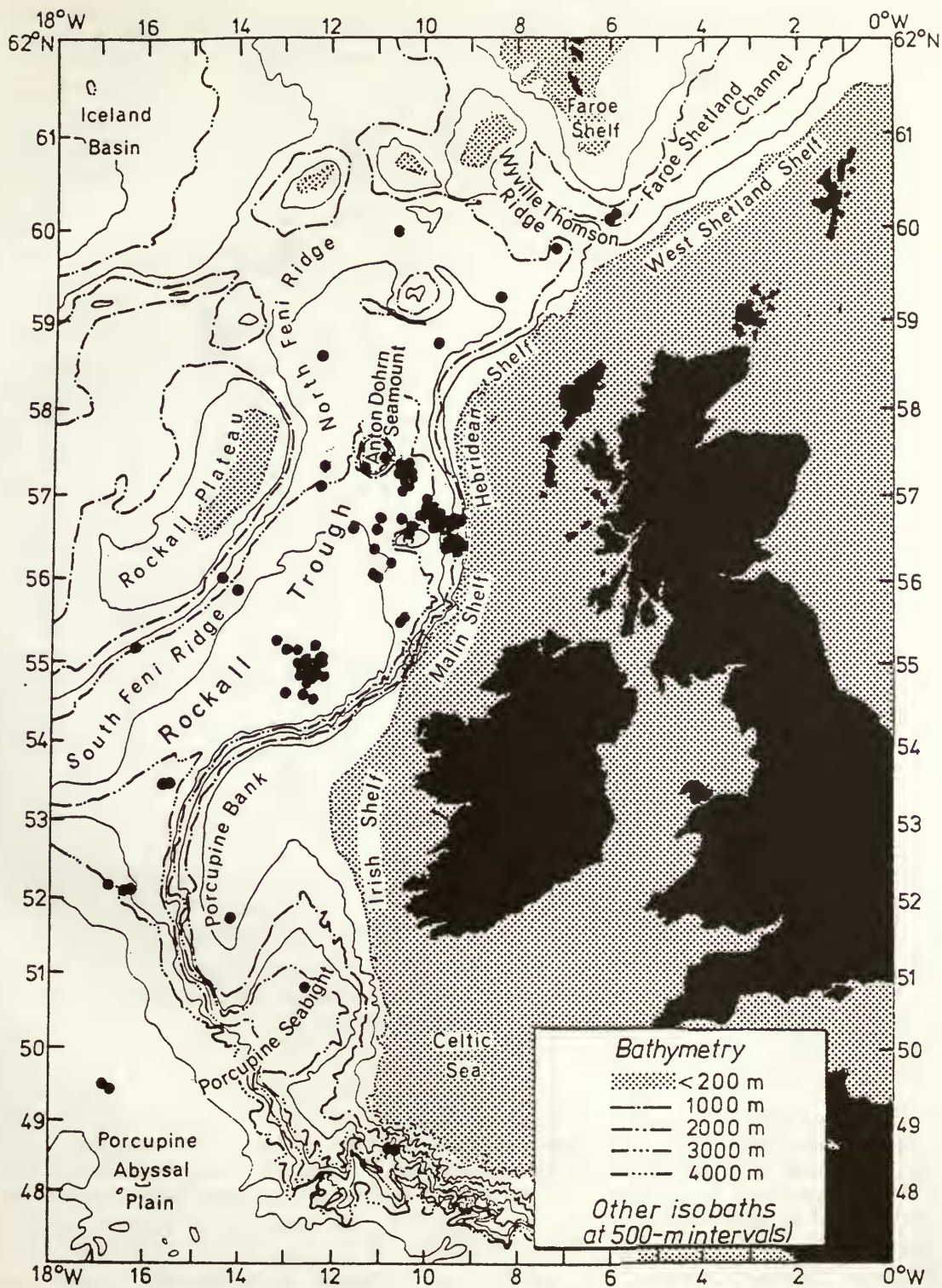


Fig. 1 Bathymetric chart of the area sampled showing locations of stations yielding records of echinoids and holothurians.

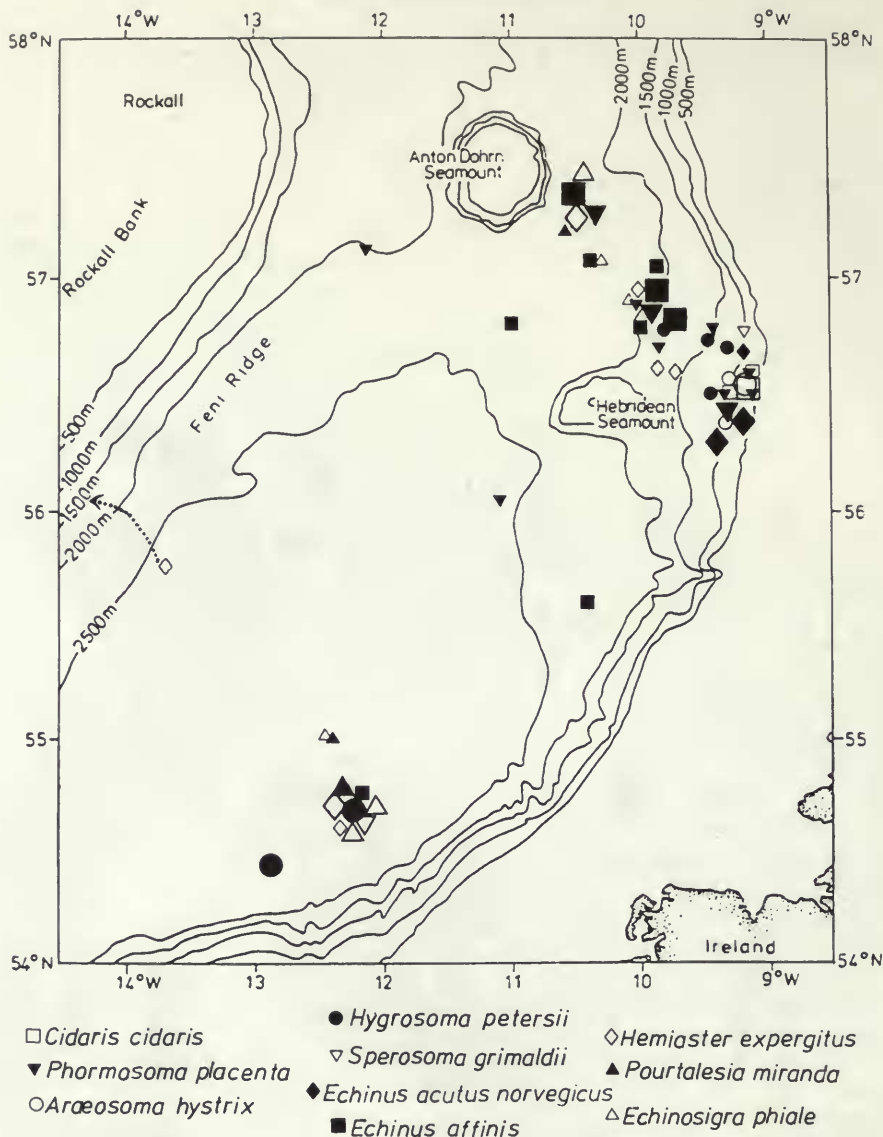


Fig. 2 Chart of central part of Rockall Trough showing station locations for records of the ten most abundant echinoid species.

The present records are from the Hebridean Slope, the Porcupine Bank and Anton Dohrn Seamount and were all taken at depths less than 1000 m on bottoms of sandy ooze to fine calcareous sand. There are numerous previous records of this species, as *C. papillata* (Leske), from the waters west of the British Isles, particularly on the rough ground of the deeper fishing grounds such as the Rockall and Lousy banks. The deepest previous record in this area was that of Farran (1913) at 1293 m in the Porcupine Seabight.

REMARKS. The long, heavily built spines of this species, although usually recovered broken, often carried a variety of encrusting organisms that were attached, presumably beyond the range of the impressive battery of pedicellariae covering the test. It was also noted that the spines of small

specimens (<40 mm test diameter) in some cases are more than three times as long as the diameter of the test.

The dietary items previously recorded for this species are summarised by De Ridder & Lawrence (1982).

**REPRODUCTION.** The sexes are separate; females produce numerous small eggs up to 110 µm in diameter (Tyler & Gage, 1984*b*). The larva is well known (Prouho, 1888; Mortensen, 1927), being a typical echinopluteus but possessing no postero-lateral arms.

*Poriodidaris purpurata* (Wyville Thomson, 1872)

*See:* Mortensen, 1903: 41–42, pl. 6, fig. 12, pl. 8, fig. 22, pl. 10, figs 1–2, 5, pl. 11, figs 3, 21; 1927: 274–275, figs 153, 154; 1928: 104–107, pls 1, 6, pl. 3, figs 3–5; Phelan, 1970: 16–17, pl. 10, figs 2–8, pl. 11, figs 1–6, pl. 12, figs 6, 7.

**SAMPLE.** GT 17(2), [1190–1296 m]

**DISTRIBUTION.** South and SW. of Iceland, northern Rockall Trough, off SW. Ireland, the Bay of Biscay, off the Canaries and in the Caribbean; 300–1800 m; on muddy bottoms.

This handsome species was first discovered by Wyville Thomson from a dredging by the *Porcupine* on the southern flank of the submarine ridge that was later named after him. The present record from the Hebridean Slope fits in well with the known distribution of this species which would appear to be geographically wider than that of *Cidaris cidaris*. Phelan (1970) in giving a bathymetric range of 750 to 1800 m did not include the shallower Icelandic records given by Einarsson (1948). However, it still seems likely that this species will be found to have a slightly deeper limit than that of *C. cidaris*.

Mortensen (1928) recorded bottom material and fragments of crustaceans in the gut contents of this species.

**REPRODUCTION.** The sexes are separate; *P. purpurata* produces large eggs up to 1400 µm in diameter suggestive of direct development (Mortensen, 1927; Tyler & Gage, 1984*b*).

Order ECHINOTHURIOIDA  
Family ECHINOTHURIIDAE

*Araeosoma fenestratum* (Wyville Thomson, 1869)

*See:* Thomson, 1874: 741, pl. 63, figs 9, 10 (labelled as 9a), pls 66, 67 (as *Calveria fenestrata*); Agassiz, 1880: 29, pls 13–14 (as *Asthenosoma reynoldsi*); Mortensen, 1903: 72–75 pl. 11, fig. 8, pl. 12, fig. 33, pl. 14, figs 1, 8, 14, 17, 18, 24, 32; 1927: 283–284, fig. 160; 1935: 233–237, pls 29, 30, pl. 78, fig. 11.

**SAMPLE.** AT 194 (32), [631 m]

**DISTRIBUTION.** An upper bathyal species distributed throughout the North Atlantic excluding the Norwegian Sea; 148–990 m depth; on fine sand to soft mud.

This species, like many other Atlantic echinothuriids, was first discovered by Wyville Thomson from dredgings made by the *Porcupine* off Portugal. Subsequently, *A. fenestratum* has been recorded from several localities from the Denmark Strait to the deep waters off Scotland, Ireland and Brittany, and down the American side of the Atlantic to the Gulf of Mexico.

The present specimens were from a trawling on the fine shell-sand covering the Anton Dohrn Seamount, the depth of which approaches its previously known lower limit. However, the paucity of our records may reflect a lack of sampling effort at upper bathyal depths where this species would be expected to occur.

**REMARKS.** The size of the present specimens ranged from 130 to 190 mm in diameter. Their colour agreed in general with Mortensen's (1903, 1927) descriptions, all having a pale buff colour with a brownish or purple-brown colouration being concentrated along the ambulacra. The singular tetradactylous pedicellariae described and figured by Wyville Thomson (figured also by Mortensen, 1927, fig. 160) were not found. The tridentate pedicellariae on the largest specimens

were markedly involute as figured by Mortensen (1903) with the blades measuring more than 3 mm. Another feature that has not previously been mentioned is that the aboral plates assume a chevron-like pattern as they approach the apex. This provides a useful additional feature to differences in test colouration and pedicellariae (see Mortensen 1903, pp. 52–53) in distinguishing this species from the closely similar *C. hystrix*.

De Ridder & Lawrence (1982) summarised the various gut contents, including bottom material, a gastropod, crustacean skeletons and woody fragments of terrestrial plants.

**REPRODUCTION.** Examination of the gonads shows the sexes to be separate; ripe oocytes that are occasionally in excess of 1200 µm in diameter were found together with two types of phagocytic tissue similar to those in *Phormosoma placenta*. A lecithotrophic or direct development of the fertilised egg to a benthic juvenile stage is predicted for this species (Tyler & Gage, 1984b).

### *Calveriosoma hystrix* (Wyville Thomson, 1869)

*See:* Mortensen, 1903: 70–72, pl. 3; figs 1–2, pl. 11, figs 5, 29, pl. 12, fig. 34, pl. 13, figs 17, 18, pl. 14, figs 13, 26 (*Calveria hystrix*); 1927: 282–283, fig. 159 (as *Araeosoma hystrix*); 1935: 222–227, figs 126–128, pl. 23, figs 1–5, pl. 24, fig. 1, pl. 78, fig. 12.

**SAMPLES.** ES 23(6), ES 178(15), AT 3(3), GT 1(1), GT 7(5), GT 11(4), GT 14(3). [650–805 to 1000 m]

**DISTRIBUTION.** Throughout the North Atlantic excluding the Norwegian Sea. On the eastern side *Calveriosoma hystrix* is known from south of Iceland down to the Canary Islands; about 180–1800 m; on muddy sand to soft ooze.

The specimens were recovered from hauls between comparatively narrow depth limits on the Hebridean Slope, *C. hystrix* being absent from the numerous hauls taken at greater depths. This may indicate a rather narrow zonation with depth. However, the *Michael Sars* recorded it from 1100–1300 m in the northern Rockall Trough [Greig, 1921 (& 1932)], whilst according to Farran (1913) it 'seems, off the Irish coast, to be a characteristic inhabitant of the ooze between 500 and 700 fathoms' (916–1282 m). This indicates that these limits may vary slightly for different areas.

**REMARKS.** The colour of the present specimens varied from a pale pink to pale red, the largest measuring 242 mm in diameter after preservation in spirit. The tridentate pedicellariae of this and other large specimens varied slightly from the description of Mortensen (1903, pp. 70–71) who found that the edges of the terminal part of the highly involuted blade of the largest pedicellariae are almost 'straight cut off' and irregularly serrated, and more regularly serrated in pedicellariae of smaller specimens. Here the serrated edges of the terminal part are slightly undulating in profile.

**REPRODUCTION.** The sexes are separate; the largest oocyte found was in excess of 1250 µm in diameter (Tyler & Gage, 1984b), although the general histology of the female appears similar to that of *Phormosoma placenta*.

### *Hygrosoma petersii* (A. Agassiz, 1880)

*See:* Agassiz, 1881: 76. Mortensen, 1927: 284–285, figs 156, 158, 161; 1935: 202–208, pls 13–17, pl. 18, fig. 2, pl. 19, fig. 2, pl. 78, figs 1, 3–5, 24, 25.

**SAMPLES.** ES 20(1), ES 129(1), AT 229(2), SWT 18(1), SWT 27(1), OTSB 51301 (?), GT 17(?). [1237–2965 m]

**DISTRIBUTION.** Throughout the North Atlantic; 730–2870 m; on soft ooze.

Although *H. petersii* was first discovered by Alexander Agassiz from *Blake* trawlings off the West Indies and the east coast of North America, it was subsequently found in the eastern North Atlantic from the Azores and off Gibraltar to the Bay of Biscay and off SW. Ireland.

The present records slightly extend the known northward range into the Rockall Trough and the known lower bathymetric limit.

**REMARKS.** The specimens had lost the majority of their primary spines on the aboral surface; however, sufficient of the characteristically scarcely curved hoofed spines remained to charac-



terise them along with the single rows of tubefeet on the oral side and the deep violet coloured skin that is largely lost by abrasion on trawled specimens, the denuded test being paler coloured.

Both Grassle *et al.* (1975) and Pawson (1982) provide interesting notes on this species from observations from the submersible *Alvin*. Grassle *et al.* diving at 1800 m depth off New England describe *H. petersii* as a 'large, black urchin with long thin spines'. They observed also that *H. petersii* was active, walking about on its ventral spines, the hoof-like tips of which were conspicuously white, so that it was quite difficult to catch using the submarine's mechanical arm. Pawson (1982) remarked that the intestinal contents of specimens collected from the Tongue of the Ocean, Bahamas, consisted almost exclusively of fragments of *Sargassum* and *Thalassia* whilst specimens collected further north appeared to have a more 'mixed' diet. Hence it seems likely that this species is an opportunistic scavenger, like other deep-sea echinothuriids.

REPRODUCTION. Examination of the gonads indicates the sexes to be separate. In the single female examined oocytes up to 1150  $\mu\text{m}$  in diameter were present (Tyler & Gage, 1984*b*).

### *Sperosoma grimaldii* Koehler, 1897

See: Mortensen, 1903: 75–78 pl. 4, figs 3–5, pl. 11, fig. 9, pl. 12, fig. 16, pl. 13, figs 12, 23, pl. 19, figs 2, 4, 4a, 6, 11, 31, 33; 1927: 287–288, fig. 163; 1935: 185–187, figs 107, 108, pl. 8, figs 1, 2.

SAMPLES. ES 99(1), AT 121(3), ES 135(1), AT 221(juvenile, 1), AT 223(1), AT 230(60, ?[juveniles], 23). [1075–2910 m]

DISTRIBUTION. Throughout North Atlantic; 300–2300 m; on soft ooze.

This species was first discovered in trawlings made in the Azores by the Prince of Monaco, its name being taken from the Monagasque royal house. It was subsequently found by the *Michael Sars* in the northern Rockall Trough at 59°28'N, 08°01'W, referred to as the 'Faroe Channel, warm area' by Mortensen (1927), and in the Porcupine Seabight by the *Helga*, recorded by Farran (1913).

REMARKS. The size of the present specimens varies from 120 to 160 mm in diameter which is somewhat less than the maximum 220 mm given by Mortensen (1927). The most abundant catch was in a trawling made on the Hebridean Slope at 1210 m depth.

REPRODUCTION. The sexes are separate; maximum oocyte size observed in female gonads 1100  $\mu\text{m}$  in diameter, but few oocytes were found to exceed 500  $\mu\text{m}$  diameter in the specimens examined (Tyler & Gage, 1984*b*).

## Family PHORMOSOMATIDAE

### *Phormosoma placenta* Wyville Thomson, 1872

See: Thomson, 1874: 732, pls 62, 63; Agassiz, 1883: 30, pls 12, 13; Mortensen, 1903: 66–70, pl. 4, figs 1–2, pl. 11, figs 7, 10, 25, pl. 12, figs 2–3, 7, 11, 19, 21, 23, 25, 26, 37, 39, pl. 13, fig. 7; 1935: 125–135, pl. 1, figs 1–5, pl. 2, figs 1–19, pl. 74, figs 1–6, 9.

SAMPLES: ES 4(1), ES 20(4), ES 22(4), SBC 67(frag.), AT 68A(juveniles, 2), ES 99(1), ES 105(2), AT 107A(3), AT 161(2), AT 162(140), AT 171(2), AT 177(2), ES 178(4), AT 181(1), AT 186(1), AT 191(juveniles, 10), AT 192(315; juveniles, 1), SWT 10(53), SWT 11(1), SWT 17(134), SWT 18(29), SWT 32(85), AT 3(3), GT 1(3), GT 11(1), GT 14(1), GT 17(5). [650–800 to 2225 m, but see note below]

DISTRIBUTION. North Atlantic from the West Indies to the Davis Strait and from off Iceland and the Faroes south to the Gulf of Guinea in South Atlantic; 260–2484 m; on muddy sand to soft ooze.

We think that the single specimen recorded from a haul at 2500–2560 m (SWT 11) may have been a contaminant from a haul (SWT 10), yielding numerous *P. placenta*, made the previous day in shallower depths nearby. Hence, this record is not taken as an extension of its known vertical range.

This now well-known and easily recognised species was first discovered by Wyville Thomson in dredgings made by the *Porcupine* in the northern Rockall Trough in the year 1869. Mortensen (1903) states that it is essentially a bathyal species 'scarcely occurring in the great depths in the

Atlantic', and indicates that it is probably absent in the 'cold' water areas north of the submarine sills dividing the Norwegian Sea from the North Atlantic. Our records confirm this distributional trend.

Le Danois (1948) regarded *Phormosoma placenta* along with the other echinothuriids, *Calveriosoma hystrix* and *Sperosoma grimaldii*, as characteristic of the faunal association found at 1000–2000 m depth on the NE. Atlantic continental slope.

According to Mortensen (1935), the gut contents include mud pellets, the animal feeding off organic material in the sediment. Pequegnat & Jeffrey (1979) found large numbers of this species in the Gulf of Mexico and western Caribbean to be associated with aggregations of terrestrial vegetation, sea grass and natural tar deposits. Although these authors thought that the plant material was eaten, it is not known whether the hydrocarbon residue is utilised as food.

REMARKS. Grassle *et al.* (1975) observed dense aggregations of this echinothuriid species from the submersible *Alvin* on the bottom at 1300 m depth off New England, although such aggregations of *P. placenta* were not observed by Pawson (1982) from *Alvin* in the Tongue of the Ocean, Bahamas.

REPRODUCTION. Histological examination of the large gonads of specimens from sta. 'M' and elsewhere shows that the sexes are separate and that this species produces large, yolky eggs in excess of 1100 µm in diameter indicative of lecithotrophic or direct development. The gonads are packed with nutritive phagocytic tissue, one type of which appears to provide energy for growth of gametes whilst a second type results from breakdown of relict gametes. There does not appear to be any seasonal cycle in oogenesis indicating that this echinoid probably breeds year-round (Tyler & Gage, 1984b).

### Order ECHINOIDA

#### Family ECHINIDAE

#### *Echinus acutus* Lamarck, 1816

See: Mortensen, 1903: 152–159, pl. 1, figs 4, 7–8, pl. 2, figs 1, 2, 6, 8, pl. 15, figs 2, 14–16, pl. 16, figs 2, 5, 10, 16, 18, 22, pl. 18, figs 1, 5–7, 14, 24; 1927: 305–306, figs 144(2), 148(1), 174; 1943: 41–52, pl. 3, fig. 3, pl. 5, figs 1–5, pl. 7, figs 7–9, pl. 8, figs 1–10, pl. 10, figs 1, 2, pl. 54, fig. 26.

SAMPLES. ES 23 (26, ?[juveniles] 5), ES 69(3), AT 223(64), AT 230(5) AT 1(1), AT 3(10), GT 1(2), GT 7(3), GT 14(3), GT 17(5). [750–1210 m]

DISTRIBUTION. North-east Atlantic including the coastal seas around Europe from Bear Island and the Barents Sea south to Cape Bojador, NW. Africa, and the Mediterranean; 20–1280 m; on fine sand to soft mud bottoms.

REMARKS. This well-known and common, morphologically variable, coastal species is known as one of three varieties: *flemingii*, *mediterraneus* and *norvegicus* each of which was thought originally to be a distinct species.

The present specimens may all be referred to *E. acutus* var. *norvegicus* as defined by Mortensen (1903, 1927, 1943). Although the shape of the test was usually low and slightly conical with a distinctly flattened oral surface, a few specimens were found with a more globular shape. Test and spine colouration, as in previous records, was highly variable. However, pedicellariae were typical of *E. acutus* in all specimens examined. In some cases the spines were an intense scarlet red with whitish tips, and the test a ruddy brown colour, in others the spines were greenish with the test showing a brown or red-brown radial pattern over the aboral side. The maximum size was 79 mm in test diameter which is well within the maximum of ca. 150 mm given by Mortensen (1943).

Although rather modest numbers have been preserved from trawlings from the Hebridean Slope, large numbers of urchins that J.D.G. has identified as this species were collected in Granton otter-trawl hauls from depths between 750–1000 m on fishing cruises of RRS *Challenger* in 1975–1977. Evidently a large population exists at this level on the continental slope. Farran (1913) records *E. acutus* var. *norvegicus* from numerous *Helga* trawlings from around the 500–1200 m depth zone in the Porcupine Seabight. It seems likely that this variety has a ribbon-

like distribution on the upper continental slope and submerged banks of the NE. Atlantic. Its bathymetric range overlaps with that of *Spatangus raschi*, both species comprising characteristic elements of the upper slope benthos (Le Danois, 1948).

Observations on the varied gut contents of *E. acutus* are summarised by De Ridder & Lawrence (1982).

**REPRODUCTION.** Histological study of the gonads of *E. acutus* var. *norvegicus* from the Hebridean Slope indicates a ripening of the ovaries of females in the early spring (Tyler & Gage, 1984a). From coastal populations occurring off the south-west of Britain in the first quarter of this century, the breeding season is recorded in the summer months with a well-known and easily recognisable echinopluteus larva. Hybridisation of shallow water specimens of *E. acutus* with *E. esculentus* and *Psammechinus miliaris* has been achieved in the laboratory (Shearer, Morgan & Fuchs, 1914; Hagström & Lønning, 1961a) and similar hybridisation is thought to occur in wild populations (Mortensen, 1943; Hagström & Lønning, 1961b).

### *Echinus affinis* Mortensen, 1903

*See:* Mortensen, 1903: 150–152, pl. 5, figs 4, 8, pl. 15, figs 3, 10, pl. 16, figs 6, 10, pl. 18, figs 4, 16, 28, pl. 19, fig. 17, pl. 20, figs 17, 21; 1943: 83–86, pl. 11, figs 1–7, pl. 55, figs 15, 17, 19.

**SAMPLES.** ES 4(47), ES 12(9), ES 14(1), ES 112(?[juveniles], 1073), AT 114(1), AT 139(4), AT 144(148), AT 151(100), AT 153(180, ?[juveniles] 1), AT 161(?1), AT 167(220), AT 171(222), AT 175(43), ES 176(7, ?[juvenile] 73), AT 177(546), AT 181(615), ES 182(18), ES 184(84), AT 186(486), AT 191(1), AT 195(487), ES 197(110, ?[juveniles]8), AT 198(75), ES 200(62, ?[juveniles]1), AT 201(223), ES 202(1), ES 218(6, ?[juveniles]), AT 219(327), AT 221(1), AT 228(941), SWT 10(282), SWT 13(3), SWT 17(15), SWT 18(182), SWT 32(5). [1605–2450 m]

**DISTRIBUTION.** Previously known in North Atlantic from south of Iceland, the Denmark Strait, and off the east coast of North America to the Azores; 770–2230 m; on soft ooze.

The present records extend both the lower limit and the known range of this species in the NE. Atlantic.

**REMARKS.** The maximum size of the specimens was 48 mm in test diameter, which is close to the 51 mm maximum given by Mortensen (1943). The size distribution of samples taken from a repeat station at *c.* 2200 m depth where this urchin was abundant was variable, being generally unimodal or sometimes bimodal, with modes from about 26 to 40 mm. The colour of test and spines was generally white with sometimes a slight buff colouration of the musculature of the base of the spines. In some of the shallower specimens (SWT 10, SWT 17 and SWT 18) this was more pronounced as a red/brown colouration imparting a faint radial colour pattern. In small specimens the pink coloured gonads show through the aboral test imparting a faint pinkish hue. Clearly this small, white urchin is abundant at suitable depths in the Rockall Trough. It is probably similarly abundant elsewhere in North Atlantic at suitable depths; Grassle *et al.* (1975) record counts of 259 and 262/100 m<sup>2</sup> from observations from the submersible *Alvin* off New England at around 1800 m depth. It is significant that they saw *Echinus* only once on dives nearby at the shallower depth of 1300 m indicating a bathymetric range of *E. affinis* there probably similar to that for this species in Rockall. A similar bathymetric distribution is indicated by Rowe & Menzies (1969) from bottom photographs taken off the Carolinas. These photographs indicate densities of 0.1–1.0 per photograph (each covering 6.3 m<sup>2</sup>) at around 2500 m depth (Rowe, 1971). Haedrich, Rowe & Polloni (1980) record that *E. affinis* ranked fourth and third, respectively, in numerical abundance of megafauna in trawlings at 1384–1947 m and 2116–2481 m off the continental slope south of New England.

Mortensen (1903) remarked that this species had probably been confused with others in sampling prior to the *Ingolf*, notably as *E. norvegicus*. He also remarked that it is closely allied to *E. alexandri* which appears to occur at similar depths. At the northern repeat station, at *c.* 2200 m in the central Rockall Trough east of the Anton Dohrn seamount, *E. alexandri* occurred only rarely. But in a haul from the southern Feni Ridge (ES 112) specimens identified to both *alexandrii* and *affinis* occurred in roughly equal numbers, along with large numbers of small

*Echinus* (< 5 mm) unidentifiable to species with certainty. It was noted that developing gonads were visible in specimens as small as 4 mm in diameter.

Mortensen (1943) noted that the gut of *E. affinis* was full of sediment including foraminiferans. It would appear to be an opportunistic scavenger, apparently actively foraging for phyto-detrital patches (R. S. Lampitt, Institute of Oceanographic Sciences, personal communication) and for larger plant remains which may lead to the formation of small aggregations (Grassle *et al.*, 1975).

REPRODUCTION. As with other members of this genus, the sexes are separate and roughly equal in number. Histological study of the gonad and females from sta. 'M' shows a marked oogenic cycle, ripe oocytes 90 µm in diameter being spawned probably in January/February (Tyler, Grant, Pain & Gage, 1982; Tyler & Gage, 1984a). Although early postlarval *Echinus* have been found in bottom hauls taken in May, these, unfortunately, cannot be identified with certainty as *E. affinis*.

Both a growth in size and a decrease in numbers in these postlarvae was evident from comparing samples taken in early June and late September 1973 and similarly from samples taken in late May and mid September 1980. Postlarvae have occurred only rarely in spring or summer samples taken in either year so it appears possible that successful recruitment is variable from year-to-year as occurs in shallow water echinoid populations (see Ebert, 1983 for references). Nothing is known of the age structure of the adult populations, although in view of the variable modal structure it would seem reasonable to suppose that survivorship and longevity is comparable to that in shallow-water populations of *Echinus*.

#### *Echinus alexandri* Danielssen & Koren, 1883

See: Mortensen, 1903: 146–149, pl. 5, figs 2, 3, pl. 15, figs 13, 17, pl. 16, fig. 8, pl. 18, figs 9, 11, 19, 23, 25, pl. 19, figs 16, 31, 34, 38, pl. 20, figs 1, 2, 27, pl. 21, figs 18–20, 27; 1927: 304–305, figs 167(1), 172, 173; 1943: 65–68, pl. 11, figs 8–11.

SAMPLES. ES 15(11), ES 20(2), AT 107A(1), ES 112(1), AT 167(1), SWT 18(2). [1271–2300 m]

DISTRIBUTION. North Atlantic from south of Iceland, the Porcupine Seabight, the Bay of Biscay to the Azores, possibly to Tristan da Cunha, and along the east side of North America; 365–3150 m; on soft ooze.

Although not numerous in the Rockall samples, the present records are the first for this species in the Rockall Trough and fall well within its previously recorded bathymetric limits. An overlapping, though slightly shallower distribution in Rockall compared to that for *Echinus affinis* is also indicated from the results of trawlings on the continental slope south of New England (Haedrich *et al.*, 1980).

REMARKS. The maximum size was 51 mm which is a little larger than the maximum for *E. affinis* although in other respects these species appear closely similar. As noted by Mortensen (1903, 1927), *E. alexandri* may be distinguished by its more flattened appearance on the upper side and by its longer spines as well as by differences in pedicellariae figured by Mortensen (1903). A further reliable difference lies in the marked black pigmentation of the tissues around the oral teeth. The light pink colour remarked on by Mortensen (1927) was not noticed in the present specimens, except in young specimens where the developing gonads showed through the thin test, although it is possible that it faded quickly in spirit and was overlooked.

Mortensen (1943) records the gut contents of *E. alexandri* as consisting of bottom mud with foraminiferans.

REPRODUCTION. Preliminary study of the histology of the gonads of *E. alexandri* shows that the sexes are separate with a well-defined oogenic cycle with probable ripening in late winter as with *E. affinis* (Tyler & Gage, 1984a). Likewise maximum egg size (100 µm) indicates planktonic development.

#### *Echinus esculentus* Linnaeus, 1758

See: Mortensen, 1927: 297–299, fig. 168; 1943: 25–40, pl. 1, figs 1–3, pl. 2, figs 1–4, pl. 3, figs 1–2, pl. 4, figs 6–11, pl. 5, fig. 6, pl. 9, fig. 1, pl. 54, figs 1–7.

SAMPLE. ES 113(1) [168 m]

DISTRIBUTION. North-east Atlantic from the coasts of Finmark and Iceland to Portugal, also known from Lousy Bank; 0–1264 m; on rocky bottoms.

The single, small specimen was taken in a haul from the Rockall Bank. Although reported by the *Ingolf* as deep as 1264 m, *E. esculentus* is uncommon at such depths and usually found only in the shallow waters of the coastline. Hence the new record, while not unexpected on Rockall Bank since it is already known from Lousy Bank, is near its usual lower limit; as Farran (1913) comments 'the occurrence of the common urchin below fifty fathoms seems to be exceptional'.

*Echinus elegans* Düben & Koren

See: Mortensen, 1903: 142–145 pl. 1, figs 2, 3, pl. 3, fig. 4, pl. 15, fig. 4, pl. 16, figs 3, 19, pl. 18, figs 2, 3, 22, 26, pl. 19, figs 10, 26, pl. 20, figs 8, 9, 19, 22, 23; 1927: 303–304, figs 167, 169; 1943: 61–68, pl. 12, figs 1–8, pl. 13, fig. 1, pl. 14, figs 1–6.

SAMPLES. ES 23(99), AT 230(2), GT 11(9), GT 14(2) [704–1210 m]

DISTRIBUTION. North-east Atlantic from Lofoten and the Trondheimfjord to the Skagerrak, and from south and west of the Shetlands and south of Iceland to the Bay of Biscay, the Azores and the North African coast to Cape Spartel; 50–1710 m; on soft sediment.

REMARKS. This species occurred along with *E. acutus* var. *norvegicus* in ES 23 and AT 230. Specimens ranged from 11 to 66 mm test diameter. The test is usually white with purplish-brown coloured spine musculature and tube feet, although some specimens had a reddish, or occasionally bright green, flush on the apical plates that sometimes continued down the dorsal test between the spines, and was present also on the spines with a white tip.

REPRODUCTION. Mortensen (1943) suggested on the basis of the small-sized eggs that *E. elegans* produced a typical Echinopluteus larva.

Order *SPATANGOIDA*

Family *AEROPSIDAE*

*Aeropsis rostrata* (Wyville Thomson, 1876)

See: Mortensen, 1907: 90–97, pl. 5, figs 8–10, 15, 20, 22, pl. 15, figs 1, 2, 5, 8, 13, 19–21, 29, 37, 40, 43, 52; 1950: 328.

SAMPLES. ES 10(1), ES 56(6), SBC 66(juveniles, 4), SBC 67(?[juvenile] 2), ES 185(1), ES 207(1, juvenile 1). [1200(?1000)–2907 m]

DISTRIBUTION. Previously known from the NW. Atlantic, from the Davis Strait southwards to the deep waters off New Zealand; *c.* 2550–3125 m. Although Agassiz (1881) referred to records of *Aeropsis rostrata* from the Bay of Biscay and coast of Portugal, Mortensen (1907, pp. 93–94) casts doubts on their authenticity. However, the present records indicate that this curious species may be found throughout the North Atlantic at suitable depths.

REMARKS. The largest specimen measured only 8.8 mm in test length compared to the maximum of 34 mm of specimens collected by the *Ingolf* and it seems likely that the present specimens are juveniles. In view of the well-developed fasciole, larger specimens may burrow deeper than the juveniles and hence be missed by the epibenthic sled sampler employed. The two extremely large penicillate tube feet seen in the present specimens, the sucking disk of which Mortensen (1907) notes is the same size in both large (where up to 12 sucking tube feet are developed) and small specimens, indicates a rather specialised function. The function of these large and highly modified tube feet with their webbed discs is unknown (Smith, 1980*a*). It is possible that they assist both in the construction and maintenance of a siphonal tube to the sediment surface, where they may protrude and assist both in feeding and in creating a respiratory current. McCauley & Carey (1967) remarked that the closely related Pacific species *A. fulva* (Agassiz, 1898) 'appears to digest organic material ingested with the sediments because the guts were largely filled with amorphous material, and only a few diatom frustules and sponge spicules could be recognised'.

## Family HEMIASTERIDAE

*Hemiaster expergitus* Lovén, 1874

*See:* Mortensen, 1907: 97–108, pl. 2, figs 1, 4, 18, 20, pl. 4, figs 6–8, 10–12, pl. 15, figs 9, 16–18; 1927: 323–324, figs 186, 187; 1950: 387–389.

SAMPLES. ES 4(9), ES 27(juvenile, 1), SBC 58(1), SBC 63(juvenile, 1), SBC 66(postlarvae 4), SBC 68(1), ES 105(1), ES 118(juvenile, 1), ES 129(1), ES 137(1), ES 143(1), AT 144(1), AT 181(2), ES 184(juvenile, 1), AT 186(2), ES 190(2), ES 200(? 1, (juvenile) 1), ES 202(1, ?[juvenile], 2), ES 204(?[juvenile], 1), SBC 205(postlarva, 1), SBC 216(1), AT 219(9), AT 221(4). [1200–2910 m]

DISTRIBUTION. Previously known throughout the North Atlantic from south of Iceland and the Davis Strait to the West Indies and in the east, the Porcupine Seabight and the Azores and Cape Verde Islands; 950–3200 m; burrowing in soft ooze.

The present records fall within the known bathymetric range although they extend the geographical range to the Rockall Trough. Mortensen (1927) casts doubts on the authenticity of the *Michael Sars* record in 1902 from 61°40'N, 03°11'E (400 m depth, temperature 6.34°C) north of the Viking Bank in the northern North Sea.

REMARKS. The largest specimen measured 32 mm in length and was recovered from a box core sample (SBC 216) where it was discovered lying in its burrow 12 cm from the surface of the sediment. A long, slightly oblique, siphonal burrow could be traced linking it to a shallow depression and opening in the sediment.

Analogies on functional morphology may be drawn from the results of the detailed studies on the shallow-water amphisternate spatangoids, *Echinocardium* and *Moira* (Nichols, 1959; Chesher, 1963; Péquignat, 1970). The large sucker-like disk and highly extensible stem of the conspicuous, brown-coloured tube feet of that part of the anterior ambulacrum lying within the roughly oval mucus-secreting peripetalous fasciole probably have a feeding function. They may also be used to construct and maintain the siphonal tube, the full length of which they are probably capable of extending. Certainly, the width and size of the peripetalous fasciole suggests a capability for generating a strong current while the opening of the funnel in the bottom of a shallow depression may serve as a trap for particles carried along by currents over the sediment surface.

## Family SPATANGIDAE

*Spatangus raschi* Lovén, 1869

*See:* Mortensen, 1907: 129–132, pl. 1, figs 4, 5, pl. 2, fig. 19, pl. 16, figs 17, 23, 28; 1927: 329–330, figs 192, 193; 1951: 14–15.

SAMPLES. ES 23(6), AT 132(1), GT 7(1), GT 14(2). [225–761 m]

DISTRIBUTION. From the Norwegian coast off Tromsø, Porcupine Seabight, Bay of Biscay to Gibraltar, also west and south of Iceland; 150–1500 m; on muddy bottoms.

The present records are from the upper Hebridean Slope except for AT 132 which was a haul on the Porcupine Bank. Large numbers of this species were obtained at depths from 146 m to 1024 m in the Porcupine Seabight and Porcupine Bank areas by the *Helga* (Farran, 1913). The numbers recorded above do not reflect the abundance of this urchin caught in the Granton otter trawl hauls made at around the 700 m level on the Hebridean Slope. Evidently a large population exists, along with *Echinus acutus* var. *norvegicus*, at about this depth. It is likely that both urchins have a ribbon-like zonation along the upper continental slope and outer banks lying to the west of the British Isles. The distribution of *S. raschi* overlaps that of the somewhat deeper range of *E. acutus* var. *norvegicus* (Le Danois, 1948).

REMARKS. Nichols (1959) gives some information on the semi-buried ploughing movement of this species from aquarium observations.

*Brissopsis* sp.

SAMPLES. ES 99(1). [1160 m]

REMARKS. This specimen was fragmented but could clearly be referred to this genus, the apical system possessing four clearly defined genital pores within the typical *Brissopsis* peripetalous fasciole. The test was delicate and pale fawn/white in colour with the fasciole showing up brown. The arrangement of the plates of the anterior ambulacrum outside the petal quite closely resembles the arrangement given by Mortensen (1951, p. 383, fig. 184) for *B. lyrifera*.

Pedicellariae were also recovered (Fig. 3), the single globiferous pedicellaria found agreeing somewhat with Mortensen's (1907) description of *Brissopsis alta* in possessing multiple teeth, some minutely bifurcate at the tip. The remaining pedicellariae were all tridentate, and although large (up to 1.75 mm blade length) were broadly tapering with minute teeth and probably similar to the third type of tridentate that Mortensen described for *B. lyrifera* (1951, pl. 19, fig. 10).

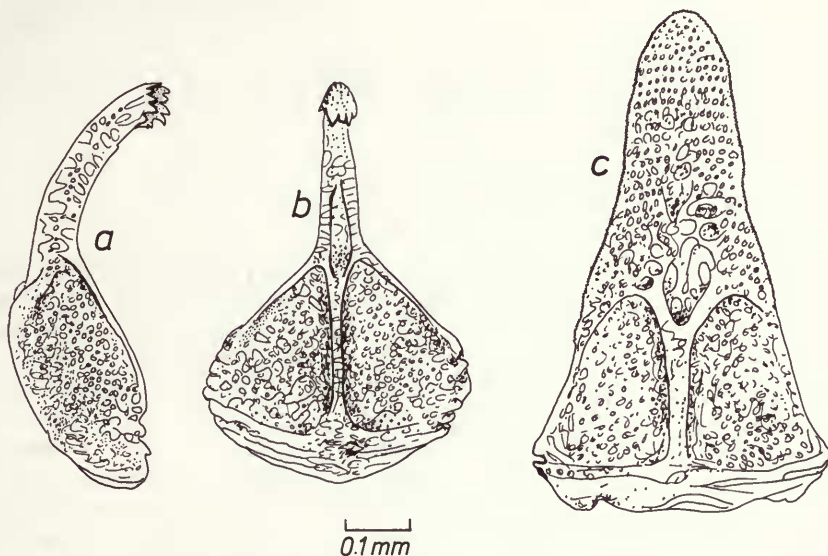


Fig. 3 *Brissopsis* sp. from ES 99: lateral (a) and inside (b) views of globiferous and tridentate (c) pedicellariae.

*Brissopsis* sp.

SAMPLE. ES 22 (fragments of several + 12 entire juveniles). [1028 m]

It is uncertain whether these specimens represent the same species as the previous *Brissopsis* sp., although in view of the similar depth this seems quite possible. The juveniles measured from 1.1 to 4.2 mm in test length.

Order **POURTALESIOIDA**  
Family **POURTALESIIDAE**

*Pourtalesia miranda* A. Agassiz, 1869

See: Mortensen, 1907: 63–68, pl. 5, figs 1–7, 11, 12, pl. 8, figs 1–3, 7, pl. 11, figs 1, 13–14, 18–20, 23, 34–37, 40–41; 1927: 346, fig. 207 (both as *P. wandeli*); 1950: 144–145.

[We follow Clark (1914) in regarding *P. wandeli* Mortensen, 1905 as conspecific with the West Indian type of *P. miranda*; see below.]

SAMPLES. ES 2(1), ES 6(41), ES 111(1), ES 118(1), ES 169(?[juvenile] 1), ES 176(1), ES 180(3), ES 185(7), ES 190(14), ES 204(56, ?[juvenile] 1), ES 207(5). [2245–2910 m]

DISTRIBUTION. Throughout the North Atlantic, from the West Indies to the Davis Strait and south of Iceland to the Bay of Biscay; 450–5850 m; in soft ooze.

Evidently, *P. miranda* is restricted to the greatest depths in the Rockall Trough, consistent with its limitation to abyssal depths, at least in the NE. Atlantic.

REMARKS. There has been considerable confusion over whether or not *P. miranda* and *P. wandeli* are conspecific, due to our lack of knowledge of the extent of variation. David (in press) describes the development of the plates and the size-related changes in shape of *Pourtalesia miranda*. Clark (1914) considered the two to be synonymous having compared specimens from western Greenland, identified as *P. wandeli* by Mortensen (1907), and from Grenada identified as *P. miranda* by Agassiz himself. Mortensen (1950) had considerable doubts about the synonymy, but maintained it concluding that 'Until a critical examination of the rich material of *Pourtalesia* from the West Indies has shown definitely that it is all only one species, I must reserve my doubts as to the identity of the said species'.

The largest of the present specimens measured 21.8 mm in length. This is considerably less than the maximum of 53 mm found in the *Ingolf* samples, although there is close agreement with the plate structure figured by Mortensen (1907). However, of the 122 specimens recovered by the *Atlantis* off Cuba, the largest measured only 25 mm long (Clark, 1941). Fig. 4 shows that slight differences in the shape and proportional size of the anal snout seen in the present specimens may be arranged in an ontogenetic series that grades into the two large specimens figured by Mortensen (1907).

Postlarvae of pourtalesiid species occurred quite often in the epibenthic sled hauls, but only sizes  $>c.$  3 mm could be distinguished from those of *Echinosigra*. Mironov (1975) has on the basis of test and spine morphology inferred that the Pourtalesiidae burrow in soft sediment. The presence of the spatulate spines on the upper, aboral side of the test in *Echinosigra* and some *Pourtalesia* was taken as evidence of their ability to burrow completely into the sediment. However, Smith (1980*a,b*) noted that there may be some doubt as to whether *Pourtalesia* is normally a burrowing species since sea-bed photographs taken both in the southern Bay of Biscay (Southward *et al.*, 1976) and off NW. Africa (Rice *et al.*, 1979) clearly shows specimens moving *over* the sediment, using their spines. Smith (1980*b*) infers from their gut contents that species of this genus are sediment swallows, and that they probably feed by ploughing forward through the sediments, funnelling the surface layer of sediment into the frontal recess.

REPRODUCTION. The sexes are separate; in females vitellogenic oocytes ranged from 90 to *c.* 300  $\mu$ m in greatest dimension; ripe eggs were filled with yoke indicating lecithotrophic development. Oocyte-size frequencies showed no significant differences between samples taken in January, April and May. Potential fecundity is around 3800 oocytes per individual but evidence of internal degeneration of oocytes suggests that actual fecundity will be less (Harvey & Gage, 1984).

#### *Pourtalesia jeffreysi* Wyville Thomson, 1873

See: Mortensen, 1907: 58–63, pl. 5, figs 13–14, 16–19, 21, 23, pl. 7, figs 2–4, 11, 12, 14, 21, pl. 8, figs 4–6, 8–11, pl. 11, figs 4, 7–10, 30.

SAMPLE. AT 90A(3). [1040 m]

DISTRIBUTION. Norwegian Sea and Kara Sea area of the Arctic Ocean, Baffin Bay; 50–3016 m; mud bottoms. The present specimens were recovered from a haul from the southern part of the Faroe/Shetland Channel, on the northern flank of the Wyville Thomson Ridge and a little south of the type locality, *Porcupine* station 64.

REMARKS. The specimens measured 30, 31 and 36 mm in length with well defined genital pores visible in all three. Large collections of this species were obtained by the *Jean Charcot* on the NORBI expedition in 1975; on the basis of a biometrical analysis of test variation David (1983)



has shown morphological differences in those from different basins in the Norwegian Sea. These differences are interpreted as an early stage in speciation as a result of geographic isolation.

Specimens of the leptonacean bivalve *Montacuta (Axinodon) symmetros* (Jeffreys, 1877) were found attached by a byssus to spines of the NORBI *P. jeffreysi* (Dr A. Warén, University of Gothenburg, personal communication). There is probably a similar association of *Montacuta symmetros* with the *Pourtalesia* in the Bay of Biscay (Dr Eve Southward, Marine Biological Association, Plymouth, personal communication and observations by J.D.G. from specimens collected by the *Jean Charcot* in the northern Bay of Biscay in 1976, INCAL cruise). Furthermore, Mironov (1978) notes unidentified montacutid bivalves attached to the ventral spines of *Pourtalesia heptneri* from the Banda Trench. There is, unfortunately, still only indirect evidence that a similar association is developed in the Rockall Trough, *Montacuta symmetros* having been found in sievings of the same hauls where *Pourtalesia* and *Echinisigra* were taken. It also remains unknown whether *M. symmetros* is restricted to one or the other species, or whether it forms an association with both.

REPRODUCTION. The sexes are separate; one of the 4 gonads present in the single female collected contained only five ripe ova averaging 225  $\mu\text{m}$  in diameter, their size and yolky appearance suggesting lecithotrophic development of the larva (Harvey & Gage, 1984).

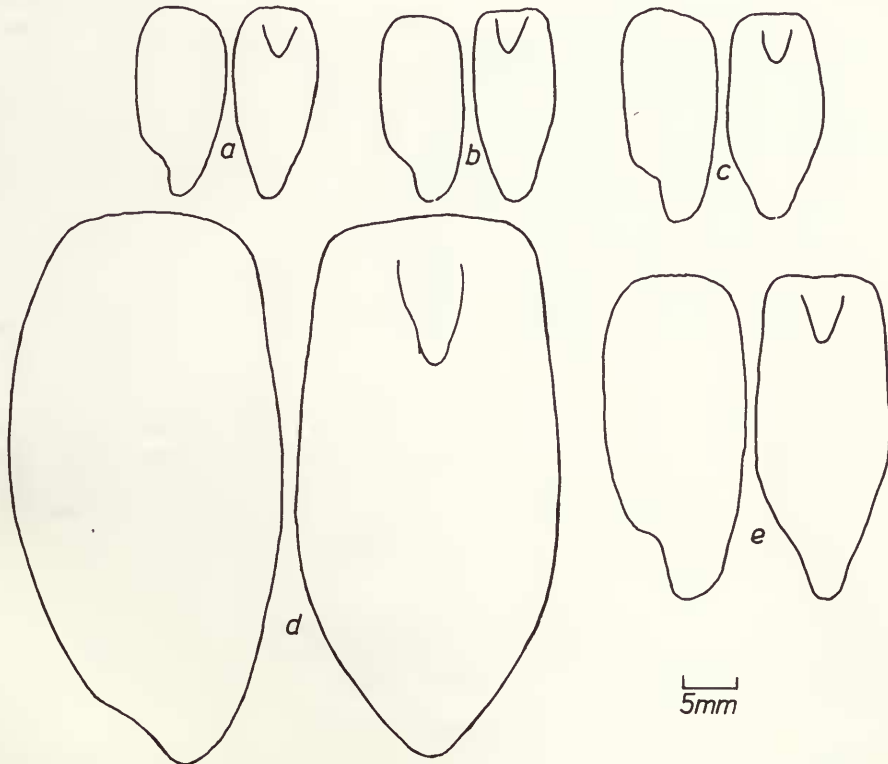


Fig. 4 Lateral and central views of tests of *Pourtalesia miranda*. a–c, present specimens from the Rockall Trough; d and e, re-drawn to scale from Mortensen (1907, pl. 5, figs 2, 6, 11, 12).

#### *Echinisigra phiale* (Wyville Thomson, 1874)

See: Mortensen, 1907, 68–72, pl. 6, figs 1, 2, 7, pl. 7, 1, 7, (as *E. phiale*); 72–77, pl. 6, figs 3–6, 17–21, pl. 7, figs 5, 10, 16, 18, pl. 11, figs 2, 3, 5, 6, 17, 21, 24, 25, 27–29, 32, 42–44 (as *E. paradoxa*); 1950: 152–153, 1532 (as *E. paradoxa*).

SAMPLES. ES 4(1), ES 6(35), ES 27(5), ES 56(3), ES 57(1), SBC 58(1), ES 59(1), ES 112(2), ES 118(5), AT 121(13), ES 129(5), ES 135(3), ES 137(5), ES 140(7), AT 141(3), ES 143(2), ES 147(?)(juvenile) 2, ES 152(3), AT 154(2), ES 164(3), AT 171(3), SBC 174(1), ES 176(5), ES 180(4), ES 185(31), ES 190(16), ES 197(3), ES 200(1), FS 204(2), SBC 205(3), ES 207(4). [1993–2912 m]

DISTRIBUTION. South and south-west of Iceland and the Rockall Trough; 1540–2377 m; soft ooze. [Mironov (1974a) refers both the *Challenger* Expedition record (Agassiz, 1881) and Mortensen's (1909) record of *E. (Pourtalesia) phiale*, both from the Southern Ocean, to the species *E. amphora* Mironov, 1974.] The present records extend the lower depth limit of *E. phiale* in the Rockall Trough.

REMARKS. On the basis of examination of the abundant material occurring in the present samples, Gage (1984a) has confirmed Mironov's (1974b) synonymy of *E. paradoxa* (Mortensen, 1905) with *E. phiale* on the basis of the original descriptions, by showing that the relatively larger specimens which Mortensen (1907) named *E. paradoxa* represent the adult form of *E. phiale* (Wyville Thomson) which was discovered originally in a *Porcupine* dredging from the Rockall Trough (56°44'N, 12°52'W, 2221 m) as juveniles. The types represent the early stages of growth before elongation to the extraordinary form of the adult. The test is differentiated into head, neck, body and tail, with usually only the head and neck being found intact in trawl hauls. Although early postlarvae could not with confidence be separated from early stages of *Pourtalesia miranda*, the elongated form and neck-like constriction in the test of stages > 3 mm could be easily distinguished as *E. phiale*. Gage (1984) traces an allometric series in growth from the *phiale* to the *paradoxa* stages. The largest entire specimen measured 51.8 mm in length whilst similar or larger sizes could be inferred from the many head-end fragments, a clear allometric relationship being established between the width of the head and total length (Gage, 1984a).

Mironov (1975) has speculated on the mode of burrowing of this and other *pourtalesiid* species. The urchin is thought to lie with a horizontal posture in a shallow burrow connected to the sediment surface by means of a short funnel above the apical system. The conspicuous circumferential fasciole on the 'tail' is thought to facilitate the removal of fine sediment and water from the burrow and produce an inward flow through the burrow entrance. Since this burrow entrance would be maintained by the activity of the tuft of spine on the aboral surface of the head, Mironov (1975) concluded that the length of these spines would determine the depth of burrowing as roughly half the height of the test.

REPRODUCTION. The sexes are separate. Gonads develop in individuals above 21 mm in length. Ripe ova were found in samples from March, April, August and November and varied from 250 to 335 µm in diameter, showing no apparent correlation with body size. Their yolky appearance suggests lecithotrophic or direct development of the larva. Size-frequency histograms for oocytes show a range of sizes, including ripe oocytes, being present throughout the year, indicating semi-continuous, year-round reproduction (Harvey & Gage, 1984).

Class **HOLOTHURIOIDEA**  
Order **DENDROCHIROTIDA**  
Family **PSOLIDAE**

*Psolus pourtalesii* Théel, 1886

*See*: Théel, 1886b: 14–15, fig. 6; Deichmann, 1930: 188–189, pl 20, figs 5–7; Heding, 1942: 36, figs 39–40, pl. 1, figs 1–2.

SAMPLE. AT 191(3). [2190 m]

DISTRIBUTION. South and SE. of Iceland, Rockall Trough, Labrador Sea, off New England and the West Indies; 1096–2271 m.

REMARKS. The present specimens measured *c.* 30 mm in length and were attached to a large boulder. It is probable that, like its congeners, *P. pourtalesii* is a suspension feeder. The presence of this holothurian on the Feni Ridge, together with a number of suspension-feeding ophiuroids

(Gage *et al.*, 1983) probably results from the high current activity in this area (Ellett & Roberts, 1973).

*Psolus squamatus* (Koren, 1844)

*See:* Mortensen, 1927: 417–419, figs 253, 254; Imoaka, 1980: 361–371, figs 1–9.

SAMPLES. GT 1(2, juveniles, 2). [713 m]

DISTRIBUTION. North-east Atlantic from SW. Ireland to the Lofoten Islands, NW. Atlantic, around the southern part of South America including the Falkland Islands, off South Africa, along the eastern border of the Pacific and off Japan; 7–1087 m. This species seems to be more common in higher latitudes.

REMARKS. The wide separation of localities has led to some uncertainty as to whether all the records could be referred to the same species. Ekman (1925) proposed that a southern form could be distinguished, but more recently Pawson (1969) and Imoaka (1980), using material taken off Chile and Japan respectively, have proposed that all the records should be referred to the same species.

*P. squamatus* is a suspension-feeding holothurian and is commonly found on stones and boulders. The feeding mechanism for the related species *P. chitinoides* has been described by Fankboner (1978).

Family CUCUMARIIDAE

*Abyssoecucumis abyssorum* (Théel, 1886)

*See:* Théel, 1886a: 66–69, pl. 4, figs 6–7, pl. 5, fig. 1, pl. 16, fig. 6; Heding, 1942: 33–35, figs 34–36; Cherbonnier, 1941: 93–96, figs 1, 3: j, n–p.

SAMPLE. SWT 15(1). [4810 m]

DISTRIBUTION. Cosmopolitan; 869–4636 m. Ekman (1927) referred to a juvenile specimen from 385 m in the Antarctic but Hansen (1975) believed that it may have been misidentified. The bathymetric limits include the records of *Cucumaria shuiteri* (Ohshima, 1915) which Heding (1942) considered to be synonymous with *Abyssoecucumis abyssorum*. The present record slightly extends the known lower bathymetric limit.

REMARKS. This specimen (100 mm long) is the largest recorded in the North Atlantic although several others of a similar size were taken by the *Challenger* Expedition in the south Pacific (Théel, 1886a). The posterior end is caudiform but unlike Théel's description the skin is fairly thick and possesses many spicules. The specimen is yellowish-white in colour with numerous small light brown pigment spots distributed all over the surface, as originally described by Marenzeller (1893). The tube-feet are more abundant than drawn for the type specimen, there being about 36 in number arranged in an irregular double row along each ambulacrum. Comparison with the specimens taken by the *Challenger* Expedition indicates that such a high number is not unusual. The body-wall deposits are mainly four armed crosses lacking a spire but with one arm disproportionately developed. This arm, which protrudes obliquely from under the skin, is very spinous at its end and has several small tooth-like spines on the stem. Heding (1942) noted that this type of deposit is more common in large specimens.

Order DACTYLOCHIROTIDA

Family YPSILOTHURIIDAE

*Ypsilothuria talismani talismani* E. Perrier, 1886

*See:* Heding, 1942: 26–27, text-figs 24, 25 figs 5, 6, text-fig. 26 figs 1, 3, text-fig. 27 fig. 3, text-fig. 28 figs 1, 2, text-fig. 29, pl. 2, figs 13–16, 21–30.

SAMPLES. ES 20(7), ES 22(3), SBC 67(4), SBC 69(juveniles, 2), ES 99(3). [c. 1000–1271]

DISTRIBUTION. North-east Atlantic; 557–2018 m. The present records support Heding's (1942) suggestion that *Y. talismani talismani* is an upper slope species rarely occurring deeper than 1500 m. Heding (1942) erected another subspecies, *Y. talismani elegans*, for a specimen taken in the West Indies.

REMARKS. For taxonomic details see the description of *Y. bitentaculata attenuata*. The feeding strategy of *Ypsilothuria* is unknown. The curious tentacle arrangement in which the two lateral tentacles on opposite sides are capable of considerable elongation, probably reflects the surface deposit feeding activities of this essentially sedentary species. The closely related genus *Echinocucumis*, which is similar in its body shape and in having larger lateral tentacles, lives buried in mud with only the mouth and anal prolongations above the sediment (Mortensen, 1927):

*Ypsilothuria bitentaculata attenuata* R. Perrier 1902

See: Heding, 1942: 28–29, text-figs 24, 25 figs 1–4, text-fig. 26 figs 5–7, text-fig. 27 fig. 5, text-fig. 30 figs 1, 2, pl. 2, figs 1–2, 5–10.

SAMPLES. ES 4(28), ES 6(266), ES 8(1), ES 10(20), ES 12(4), ES 27(38, juvenile, 1), ES 34(juvenile 1), ES 52(1), ES 54(1), ES 55(10), ES 56(4), ES 57(2), ES 59(9), ES 111(8), ES 118(19), AT 119(19), AT 121(49), ES 122(12), ES 129(1), AT 130(1), ES 137(19), ES 140(32), AT 141(28), ES 143(3), AT 144(108), ES 147(21), SBC 150(1), AT 151(78), ES 152(117, juveniles 25), AT 153(239), AT 154(73), ES 164(35, juveniles 9), ES 169(8, juveniles 1), AT 171(157), ES 172(10, juveniles 21), AT 175(17), ES 176(44, juveniles, 13), AT 177(381), ES 180(17, juveniles 9), AT 181(75), ES 184(19, juveniles 15), ES 185(153), AT 186(12), ES 190(45), AT 191(7), AT 192(1), AT 195(134), ES 197(329), AT 198(1), ES 200(105), AT 201(10), ES 202(25, juveniles 13), ES 204(78, juveniles 3), ES 207(73, juveniles 3), AT 219(38). [c. 1862–2951 m]

DISTRIBUTION. North Atlantic from Davis Strait to West Africa. 1836–3231 m. Heding (1942) considered the North Atlantic specimens to be a variety of *Y. bitentaculata*. This species probably has a cosmopolitan distribution and is common in the Pacific between 250 and 4000 m (Pawson, 1965). Heding (1942) considered *Y. bitentaculata attenuata* to be a lower slope species found at depths greater than 1800 m.

REMARKS. Heding (1942) distinguished *Y. bitentaculata attenuata* from *Y. talismani talismani* on the basis of the shape and size of the calcareous plates, the shape of the deposits in the two large tentacles, and by the shape of the lateral interradial plates of the calcareous ring. A comparison of specimens of a similar size of the two species shows that the body-wall deposits of *Y. bitentaculata attenuata* are consistently larger than those of *Y. talismani talismani* although the difference in size noted by Heding (1942) may occur only in the largest specimens. The development of the deposits in the large lateral tentacles is also related to the size of the specimen (J.D.G. unpublished data). The shape of the lateral interradial plate of the calcareous ring is the most consistent taxonomic characteristic between the two species. In *Y. talismani* the plate has a tooth-shaped anterior process ending in a sharp point, while in *Y. bitentaculata attenuata* the anterior process is usually bifurcate, although in some cases it may have a simple blunt end. In all cases the anterior process is broader than in *Y. talismani talismani*. It should be noted that Heding (1942) refers erroneously to lateral radial plates on page 26, and the plates figured in text-fig. 26 are the lateral interradial and latero-ventral radial. The mid-ventral radial is only present in Figs 4 and 8.

Heding (1942) considered that differences in the body-wall deposit size and structure, and in the shape of the calcareous ring plates were sufficient to refer *Y. attenuata* as a subspecies of *Y. bitentaculata*. The North Atlantic specimens may be found in future to fall within the total variation expected for *Y. bitentaculata*.

In all of the specimens examined the gut was filled with sediment indicating a deposit-feeding mode of life as described for *Y. talismani talismani*. The large variation in the number of specimens taken between hauls probably indicates a patchy distribution.

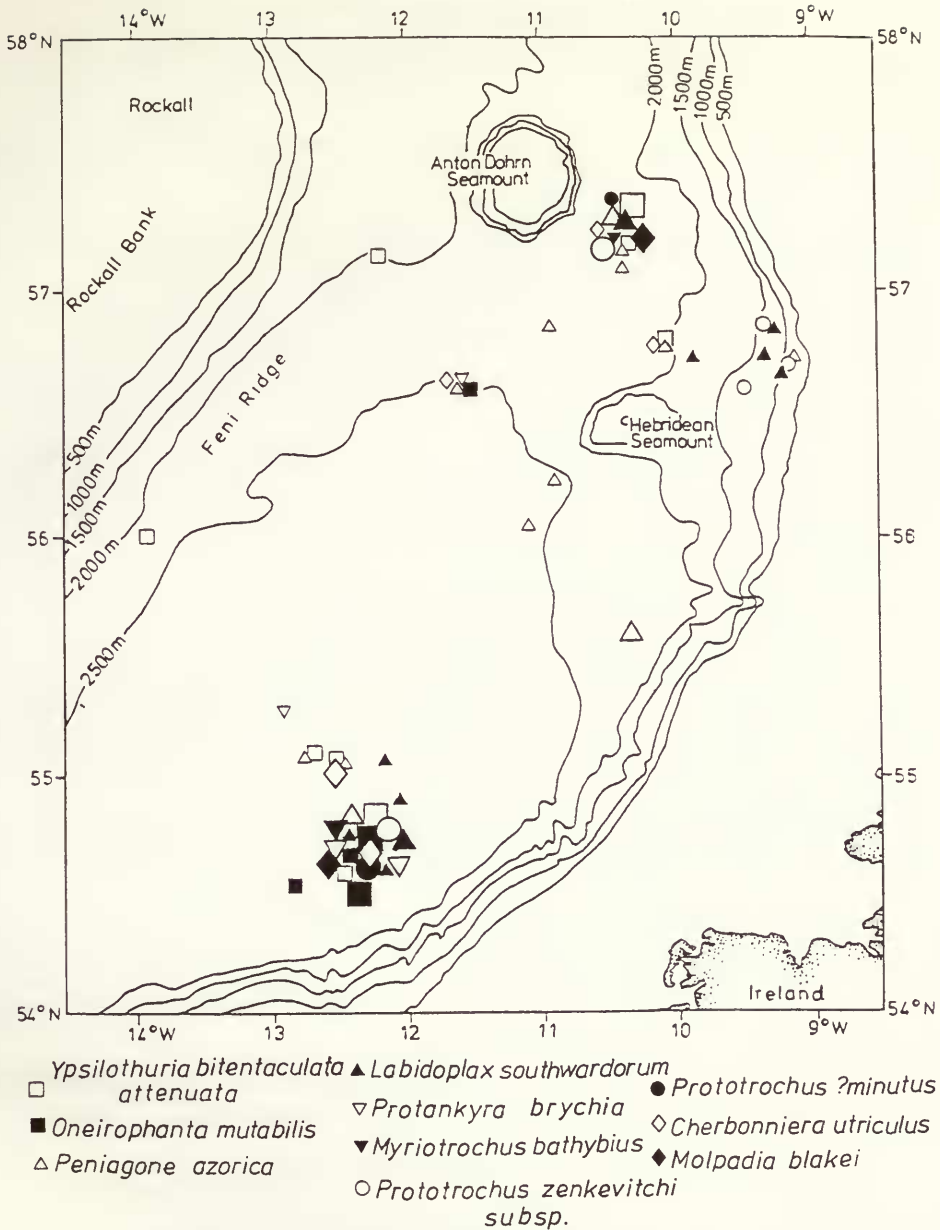


Fig. 5 Chart of central part of Rockall Trough showing station locations for records of the ten most abundant holothurian species.

REPRODUCTION. The reproductive biology of *Y. bitentaculata attenuata* was studied by Tyler & Gage (1983) under the name of *Y. talismani*. The sexes are separate. The tubules of the gonad ramify throughout the dorsal body cavity close to the gut. In females, oocyte development is synchronous within, but asynchronous between, individual tubules. Study of a time series of samples provides no evidence for annual periodicity in development of the gonads of both sexes. Oocytes grow to a maximum of 350  $\mu\text{m}$  in diameter. This, together with a maximum fecundity of up to 50 oocytes per individual, is interpreted by Tyler & Gage (1983) as indicative of an 'abbreviated', probably lecithotrophic, larval development.

*Echinocucumis hispida* (Barrett, 1857)

See: Mortensen, 1927: 404–405, figs 242, 243; Pawson, 1965: 8–10, text-fig. 1 fig. 1, text-fig. 2.

SAMPLE. SBC 67(4). [c. 1000 m]

DISTRIBUTION. North-east Atlantic, West Indies and east of New Zealand, probably cosmopolitan; 50–1400 m.

REMARKS. The specimens were obtained from the washings of a sandy mud sediment obtained by the 0.25 m<sup>2</sup> box corer on the Hebridean Slope. Four specimens of *Ypsilothuria talismani talismani* also occurred in this sample. Although possessing a similar body morphology, they may easily be distinguished by differences in the calcareous plates of the body wall. The plate of *Ypsilothuria* has a thick stereom with small holes and may be made up of several layers, particularly around the centre where the spire is found. The spire is usually a complex structure made up of many fused pieces. The plate of *Echinocucumis* has much larger holes and the spire, which is placed to one side, is made up of only a few fused pieces.

The co-occurrence of *Y. talismani* and *E. hispida* in this sample indicates an overlapping vertical range. Mortensen (1927) describes *Echinocucumis hispida* as living buried in the mud, with only the mouth and anal prolongation of the U-shaped body projecting above the sediment.

## Order ASPIDOCHIROTIDA

## Family SYNALLACTIDAE

*Bathyploetes natans* (M. Sars, 1868)

See: Mortensen, 1927: 384–385, figs 228: 2, 229; Heding, 1942: 10–12, figs 10–11, 12: 1–2; Pawson, 1965: 16–18, fig. 4.

SAMPLES. GT 17(3). [1237 m]

DISTRIBUTION. Essentially cosmopolitan; about 200 to 1600 m. In the NE. Atlantic *B. natans* usually occurs between 600 and 1600 m, rising to about 200 m off Norway.

REMARKS. The specimens were in poor condition. They were orange in colour and devoid of spicules except in the papillae on which the identification is based. Wesenberg-Lund (1941) recorded a commensal polychaete, *Harmothoë bathydomus* Ditlevsen, 1917, on *B. natans* but it was not present on these specimens. *B. natans* has long been known to be able to swim by undulating its body (Sars, 1868), hence the specific name.

REPRODUCTION. Mortensen (1927) noted that the sexes are separate and that the large, yolky eggs probably indicate direct development.

*Benthothuria funebris* R. Perrier, 1902

See: Perrier, 1902: 365–371; Heding, 1940: 363–364; 1942: 6.

SAMPLES. ES 27(1), ES 28(?juvenile 1), AT 119(1), AT 121(1), ES 147(3), ES 152(2), ES 169(1), SWT 12(1), SWT 27(1), OTSB 51001(2), OTSB 51301(7). [2890–2996 m]

DISTRIBUTION. Off NW. Africa and SW. Greenland; 782–2700 m.

The samples taken extend the lower bathymetric limit to 2996 m, and provide a geographic link between the previous records. It appears that this holothurian occurs deeper in more northerly latitudes (2700–2996) than off NW. Africa (782–1230 m). If *B. funebris* is synonymous with *B. valdiviae* Heding, 1940 (see below) then the lower bathymetric limit is 4636 m and the species extends to the Indian Ocean.

It may appear from the present samples that *B. funebris* is not a particularly common holothurian. However, this is probably due to a patchy distribution as 67 specimens were taken in one haul by an IOS trawl at the same locality as these records (D.S.M.B. unpublished data, St. 50701, 11 Oct. 1979, 2870–2890 m; 54°34'N, 11°54'W).

REMARKS. Although *Benthothuria* may be sampled in good condition the gelatinous dorsal surface is notoriously difficult to preserve, leading to difficulties in identification. Heding (1940) proposed five species for the genus *Benthothuria*, although he questioned the validity of *B. cristatus* and considered *B. funebris* to be synonymous with *B. valdiviae*. These latter two nominal species differed in two respects; the number of polian vesicles and the presence or absence of large papillae along the dorsal ambulacra. Like the *Ingolf* specimen (Heding, 1942) the Rockall specimens possess two polian vesicles, which is at variance with the single polian vesicle found in the type specimen of *B. funebris*. However, two specimens of *Benthothuria* sampled off NW. Africa (14°50'8"N, 17°50'6"W, 1430 m) in an area not far from the type locality, both also possessed two polian vesicles (D.S.M.B., unpublished data). These specimens resembled *B. funebris* in all other respects although they were larger; however, their poor state of preservation did not permit the presence of large dorsal papillae to be ascertained. Like *B. valdiviae* the Rockall specimens possess some larger papillae along the dorsal ambulacra in addition to the small papillae that are scattered over the dorsal surface, particularly in the lateral interambulacra. The large dorsal papillae are usually retracted and are exceedingly difficult to distinguish in poorly preserved specimens. Heding's proposal that *B. funebris* and *B. valdiviae* are conspecific would appear to be correct, but the matter still awaits the comparison of well-preserved specimens from the type localities. Heding's (1940) classification placing the genera *Benthothuria*, *Paroriza* and *Pseudostichopus* within the family Gephyrothuriidae under the order Aspidochirotea has been rejected by most specialists. Deichmann's (1940) classification placing the Gephyrothuriidae, with the single genus *Gephyrothuria*, within the Molpadiida, and placing the genera *Benthothuria*, *Paroriza* and *Pseudostichopus* within the Synallactidae is generally adopted. In our view, *Benthothuria* is undoubtedly a synallactid with many features in common with *Paelopatides*.

The specimens are white dorsally and purple ventrally; although fairly robust when they first reach the deck the dorsal surface soon starts to break down into a gelatinous mass. They appear to be neutrally buoyant. *B. funebris* may attain a considerable size and the dorsal surface appears to increase disproportionately in mass to the length of the animal during growth. As with *Paelopatides grisea*, the body cavity of the holothurian is less than one-third of the total body volume. Deep-sea photographs of *Benthothuria* can be found in Heezen & Hollister (1971, p. 85) and Pequegnat *et al.* (1972, pp. 90, 95).

### *Paelopatides grisea* R. Perrier, 1902

See: R. Perrier, 1902: 361–365.

SAMPLE. AT 161(3). [2055 m]

DISTRIBUTION. North-east Atlantic, 1918–4060 m, record confirms that *P. grisea* occurs generally at depths of about 2000 m. It is common at these depths in the Porcupine Seabight (D.S.M.B., unpublished data) and in the Bay of Biscay (Sibuet, 1977—recorded as *P. gigantea*).

REMARKS. The species of *Paelopatides* are sometimes difficult to distinguish owing to the damage that the gelatinous body sustains during sampling and preservation. Although Deichmann (1930) considered *P. grisea* to be synonymous with the NW. Atlantic species *P. gigantea* (Verrill, 1884), Heding (1940) believed that the two could be separated depending on the number of polian vesicles. Like the type of *P. grisea*, the present specimens possess two polian vesicles, one of which is large while the other is of variable size but generally small. Since the number of vesicles is the only known difference between *P. grisea* and *P. gigantea* and is a character of doubtful taxonomic significance, the NE. and NW. Atlantic forms of the holothurian may prove not to be specifically distinct when a thorough comparison can be made.

*Paelopatides* is almost neutrally buoyant and has been observed from submersibles to swim by undulating its body (Grassle *et al.*, 1975; Pawson, 1976). A bottom photograph, taken using a combined trawl and forward-looking deep-sea camera system, clearly shows a large *Paelopatides* > 40 cm long from 1942–1949 m depth off the NW. African coast (Rice *et al.*, 1979). It is interesting that these authors note that this specimen was not recovered in the trawl catch. This holothurian also appears to have a rather patchy distribution (Sibuet, 1977; Pawson, 1982).

Despite its gelatinous body, the organic composition of its body wall is remarkably similar to that of other deep-sea and shallow-water holothurians (Sibuet & Lawrence, 1981).

REPRODUCTION. Eggs grow to a size in excess of 1200  $\mu\text{m}$  (P.A.T. unpublished data).

*Mesothuria cathedralis* Heding, 1940

See: Heding, 1940: 336–338, fig. 5; 1942: 8–9, fig. 8.

SAMPLE. ES 10(1). [2540 m]

DISTRIBUTION. Previously known only from the Gulf of Guinea, from off Cape Bojador and in the Irminger Basin off southern Greenland; 2137–2480 m. The present record increases the lower bathymetric limit to 2540 m and provides a geographic link between these discontinuous localities in the North Atlantic.

REMARKS. The specimen is small (23 mm long) with tube-feet all over the body, small ventrally and larger laterally. The spicules are tables generally with 8 holes in the base and with a tall spire ending in four points which are almost smooth and not as thorny as figured by Heding (1940). Reduced tables are found in the tube-feet.

*Mesothuria lactea* (Théel, 1886)

See: Mortensen, 1927: 382–383, figs 226, 227; Heding, 1942: 9–10, fig. 9.

SAMPLE. ES 105(1). [1600 m]

DISTRIBUTION. Cosmopolitan, 694–5108 m. The deepest record from the South Atlantic referred to as *M. lactea* var. *spinosa* by Heding, 1940 should probably be more appropriately assigned to *M. candelabra* Hérourard, 1923. The deepest record would then become 4400 m in the North Atlantic (Sibuet, 1977). However, *M. lactea* is more abundant at shallower depths, usually at about 1500 m in the NE. Atlantic (Hérourard, 1923).

*Pseudostichopus villosus* Théel, 1886

See: Théel, 1886a: 170–171; Heding, 1940: 353–360.

SAMPLES. ES 6(1), AT 121(1). [2910 m]

DISTRIBUTION. Cosmopolitan; generally between 2515 and 7000 m, but also taken off Guadeloupe at 896 m (Deichmann, 1930). The wide bathymetric range may reflect the taxonomic difficulties evident in this genus.

REMARKS. Although Heding (1940) revised the genus *Pseudostichopus* placing *P. villosus* in the genus *Molpadiodemus* and the family Gephyrothuriidae, several authors have continued to record *villosus* under the generic name *Pseudostichopus* in the family Synallactidae (Madsen, 1953; Hansen, 1956, 1975; Lemche *et al.*, 1976; Sibuet, 1977). In view of the doubts concerning Heding's classification we have continued to record *villosus* in *Pseudostichopus*.

There are two specimens in our samples. The one from AT 121 is 160 mm long and 80 mm wide at the widest point of an almost oval shape. The skin is thick, up to 4 mm, and white in colour although the holothurian is grey in general appearance owing to a layer of foreign particles, predominantly planktonic foraminifera, which cover the epidermis. Other fauna include benthic foraminifera, hydroids and what appear to be fungal hyphae. Much of the body is covered by a mucous layer which has to be scraped off to reveal the body surface. The tube-feet are numerous and are distributed all over the body. They are generally brown in colour and are about 1 mm long in their retracted state. No deposits were found apart from small irregular rods in the tentacles. The calcareous ring is well developed and made of 10 equal-sized, broad but rather short pieces.

The second specimen from ES 6 is exceedingly small, only 6 mm long, and is tentatively referred to this species. It has a posterior vertical furrow in which the anus is placed and is covered dorsally and laterally in numerous tube-feet. However the tube-feet are scarce on the ventral



surface particularly in the middle part of the body. It has 17 tentacles which have small irregular rods but is otherwise devoid of skin deposits.

Comparison of the large individual with specimens of *P. atlanticus* R. Perrier, 1902 from the Porcupine Seabight confirms Deichmann's (1930, p. 88) proposal that Hérouard's (1923) record of *P. villosus* should be referred to *P. atlanticus*.

Deep-sea photographs of *P. villosus* can be found in Lemche *et al.* (1976, pls 21d, 22a).

Large populations of bacteria have been found in the gut of *P. villosus* (Bianchi, Scoditti & Bensoussan, 1979). This holothurian is also able to select for less dense particles when feeding and assimilates about 20% of the organic matter ingested (Sibuet *et al.*, 1982).

### Family STICHOPODIDAE

#### *Stichopus tremulus* (Gunnerus, 1767)

*See:* Mortensen, 1927: 389–390, fig. 228: 1, fig. 231.

SAMPLES. ES 113(1), AT 133(20), AT 194(6), GT 7(3). [168–689 m]

DISTRIBUTION. North-east Atlantic, Norway to the Canaries; generally 240–1918 m but may rise to as shallow as 20 m off Scandinavian coasts.

REMARKS. The ecology of *S. tremulus* is fairly well known owing to its occurrence at shallow depths (for a review see Jespersen & Lützen, 1971). *S. tremulus* is liable to infection by several parasites including the bizarre gastropod *Enteroxenos* (see Lützen, 1979) which is also found in deep water specimens (D.S.M.B., unpublished data).

*S. tremulus* is a selective deposit feeder showing a preference for the faecal pellets of other animals and sediment aggregates with a higher organic content than the surface sediment (Hauksson, 1979).

### Order ELASIPODA Family DEIMATIDAE

#### *Oneirophanta mutabilis mutabilis* Théel, 1879

*See:* Hansen, 1975: 24–32, text-figs 2–5, 94: 2, 96, pl. 8, figs 1–2, pl. 11, fig. 2, pl. 13, fig. 3.

SAMPLES. ES 28(3), AT 119(1), AT 121(15), ES 129(3), AT 130(1), ES 136(1), ES 137(1), ES 164(1), SWT 15(5). [2900–4810 m]

DISTRIBUTION. Cosmopolitan; the bathymetric range generally lies between 3200 and 6000 m. Specimens have been taken as shallow as 1804 m in the mid-North Atlantic (Hérouard, 1923) and 500 m off the Andaman Islands, Indian Ocean (reported in Deichmann, 1930), although it should be noted that in the latter case the bottom is particularly steep in this area. The new records extend the range at which *O. mutabilis mutabilis* is abundant up to 2900 m.

REMARKS. This holothurian is associated with a variety of animals including parasitic gastropods (Bouchet & Lützen, 1980), cyclopid copepods (Humes, 1974), and parasitic amphipods that have been found within the intestine (D.S.M.B., unpublished data).

REPRODUCTION. The sexes are separate, the eggs of females reaching 950 µm diameter (Hansen, 1975; Tyler *et al.*, in press) although most are <400 µm. Specimens of *O. mutabilis affinis* Ludwig, 1894 collected by the *Galathea* in the Pacific off Central America were found to show intra-ovarian brood protection. This has not been found in females collected from the NE. Atlantic (D.S.M.B. and P.A.T. pers. obs.).

It is of interest that females appear to undergo oogenesis by a pattern typical of holothurians, but there is little evidence of spermatogenesis in males. We have found no ripe males and only very occasionally do we find males in the earliest stages of spermatogenesis. A similar feature is seen in the related species *Deima validum* (Tyler *et al.*, in press).

## Family LAETMOGONIDAE

*Laetmogone violacea* Théel, 1879

See: Hansen, 1975: 58–61, text-figs 21–22, pl. 8, fig. 8, pl. 11, figs 9–10.

SAMPLES: SBC 64(1), ES 99(1), AT 162(4), ES 178(19), SWT 12(2), GT 11(2), GT 17(16). [992–1400 (3000) m]

DISTRIBUTION. Almost a cosmopolitan distribution but not recorded from the W. Atlantic or E. Pacific; 225–1804 m. Hansen (1975) considered that the distribution may be dependent on the dispersal of larvae by deep-sea currents.

The present records fall within the expected bathymetric range, except for SWT12 taken at the base of the extremely steep continental slope to the west of the Porcupine Bank. The two specimens were in good condition and not the result of contamination from a previous haul. They may represent an extension in the bathymetric range of *L. violacea*, or result from some downslope process off the Porcupine Bank.

REMARKS. Many specimens bore the marks of the commensal polychaete *Eunoë laetmogonensis* on their ventral surface (Kirkegaard & Billett, 1980). *L. violacea* is bioluminescent, emitting light from the body wall and from the tips of the dorsal papillae (Herring, 1974).

REPRODUCTION. Maximum egg size is up to 400 µm, suggestive of direct development, with no seasonal periodicity. For holothurians, this is considered an 'intermediate' egg size between the small eggs (<200 µm) of those with planktotrophic development, and the large eggs (>600 µm) of those with direct development. These eggs may give rise to an 'abbreviated' lecithotrophic larva the development of which, although not greatly prolonged, is sufficiently long to allow dispersal of larvae that need to feed away from the adult population (Tyler *et al.*, in press).

*Benthogone rosea* Koehler, 1896

See: Hansen, 1975: 48–49, fig. 15.

SAMPLES. AT 157(19), AT 161(17). [1745–2055 m]

DISTRIBUTION. Eastern Atlantic, SW. Pacific, W. Indian Ocean; 1103–2480 m.

Although the lower bathymetric limit was increased to 4100 m by Sibuet (1977) from material taken at BIOGAS st. 3, Bisol *et al.* (1984) state that *B. rosea* was taken only at BIOGAS st. 1 (1800–2200 m). The present records extend the geographic distribution in the NE. Atlantic and confirm that *B. rosea* is often common at about 2000 m.

REMARKS. When captured *B. rosea* often eviscerates and releases copious amounts of slime. It bioluminesces weakly, generally on the dorsal surface (Herring, 1974). The organic composition of the body-wall is similar to that of shallow-water holothurians (Sibuet & Lawrence, 1981) and it is able to select detrital particles that are rich in bio-available compounds (Khrifpounoff & Sibuet, 1980). *B. rosea* appears to have a patchy distribution on the bottom (Sibuet, 1977).

REPRODUCTION. Maximum egg size is 750 µm, suggestive of direct development and there is no evidence of reproductive seasonality (Tyler *et al.*, in press).

## Family PSYCHROPOTIDAE

*Psychropotes depressa* (Théel, 1882)

See: Hansen, 1975: 106–111, figs 43–44, pl. 7, figs 1–3, pl. 12, fig. 8, pl. 14, figs 1–2.

SAMPLES. ES 28(1), AT 121(3), ES 147(1), AT 181(1), ES 184(1), SWT 27(1). [2220–2965 m]

DISTRIBUTION. Throughout North Atlantic, Gulf of Guinea, Japan, Gulf of Panama and off Chile; probably cosmopolitan ranging over deeper bathyal and upper abyssal zones; 957–4060 m.

REMARKS. Pawson (1982) noted a patchy distribution for *P. depressa* in the Tongue of the Ocean, Bahama Islands.

*Psychropotes longicauda* Théel, 1882

See: Hansen, 1975: 115–126, figs 49–54, pl. 7, figs 4–6, pl. 12, fig. 7.

SAMPLES. AT 121(1), SWT 12(1), SWT 5(3). [2910–4810 m]

DISTRIBUTION. Cosmopolitan; 2210–5173 m.

REMARKS. This holothurian is often infected by the sporozoan parasite *Ixoreis psychropotae* (Massin, Jangoux & Sibuet, 1978). Its body-wall organic composition is similar to that of shallow water holothurians (Sibuet & Lawrence, 1981) and it is able to select particles of nutritional value (Khrpounoff & Sibuet, 1980) including spores and pollen (Kozyar *et al.*, 1974). A pelagic specimen referred to a new nominal sp., *Nectothuria translucida* Belyaev & Vinogradov, 1969, was taken using a closing plankton net at 4940 to 5930 m in the Pacific Ocean (Belyaev & Vinogradov, 1969). This was subsequently shown to be a juvenile of *P. longicauda* by Hansen (1975).

*Benthodytes lingua* R. Perrier, 1896

See: Hansen, 1975: 80–82, fig. 29, pl. 9, figs 3–5, pl. 12, figs 2–3.

SAMPLES. ES 27(1), ES 28(2), AT 121(1). [c. 2900–2910 m]

DISTRIBUTION. North and South Atlantic; 860–3192 m.

REMARKS. The specimens are between 120 and 150 mm long and have a gelatinous skin with cross-shaped spicules. They are pale brown dorsally, faint purple laterally, and dark brown ventrally. This species can reach a length in excess of 300 mm and has been seen to have a patchy distribution on the bottom in the W. Atlantic (Pawson, 1982).

## Family ELPIDIIDAE

*Peniagone azorica* von Marenzeller, 1893

See: Hansen, 1975: 138–142, fig. 63, pl. 10, figs 1–3.

SAMPLES. ES 2(109), ES 5(1), ES 6(43), ES 8(2), ES 10(1), ES 27(81), ES 28(38), ES 34(53), ES 52(5), ES 53(1), ES 54(14), ES 55(14), ES 56(8), ES 59(?juvenile 1), ES 110(5), ES 111(2), AT 114(2), ES 118(1), AT 119(16), ES 120(4), AT 121(76), ES 122(21), ES 129(1), AT 138(81), AT 139(64), ES 147(5), AT 154(121), ES 164(1), AT 167(11), ES 176(3), AT 219(1), SWT 11(166), SWT 13(2), SWT 16(191), SWT 27(648). [1991–3463 m]

DISTRIBUTION. *P. azorica* has a rather curious distribution. It is present in the NE. Atlantic between 1385 and 4020 m but has also been found in the Kermadec Trench between 2640 and 8210 m (Hansen, 1975). It has been photographed in other Pacific deep-sea trenches (Lemche *et al.*, 1976) and possibly within the Romanche Trench in the Atlantic (Heezen *et al.*, 1964). The present records confirm that this species is common between 2000 and 3000 m in the NE. Atlantic (Hérouard, 1923; Le Danois, 1948).

REMARKS. The specimen recorded at ES 5 (763 m) was undoubtedly a contaminant from a previous haul. The large differences in the number of specimens taken from hauls on or near 54°40'N, 12°16'W in the southern Rockall Trough may indicate a patchy distribution for this holothurian.

REPRODUCTION. Juveniles (<c. 30 mm body length) were relatively rare, the body length frequencies of all except one sample being unimodal, peaking between 42 and 53 mm. The ES 27 sample was bimodal with a peak of juvenile frequencies at c. 20 mm length as well as an adult peak at c. 47 mm. We interpret this size structure as suggesting infrequent, spasmodic recruitment to a slowly-growing adult population.

The sexes are separate. Maximum egg size observed is about 350 µm, a somewhat smaller egg size than most of the deep-sea holothurians studied to date (Tyler *et al.*, in press). These authors suggest possibly 'abbreviated' lecithotrophic development, as for *Laetmogone violacea*. Unspawned eggs appear to undergo phagocytic breakdown.

*Peniagone diaphana* (Théel, 1882)

See: Hansen, 1975: 153–155, fig. 71, pl. 10, figs 7–8.

SAMPLE. SWT 15(1). [4810 m]

**DISTRIBUTION.** Described originally from a single specimen taken in the Australian Bight by the *Challenger* Expedition (Théel, 1882), several more specimens were sampled later in the NE. Atlantic (Hérouard, 1899, 1902, 1923). More recently specimens have been observed from submersibles in the W. Atlantic (Pawson, 1976) and NE. Pacific (Barnes *et al.*, 1976). The wide separation of these records is probably due to the difficulties in sampling this benthopelagic holothurian (see below) which otherwise has a cosmopolitan distribution; 1900–5600 m.

**REMARKS.** Although Hérouard (1923) took some specimens of *P. diaphana* in pelagic nets it was not until dense populations were observed from a submersible (Barnes *et al.*, 1976) that its benthopelagic lifestyle was known. *P. diaphana*, which is capable of weak swimming movements, lives in the water column generally within 100 m of the sediment surface. Pelagic nets (RMT 1+8, Roe & Shale, 1979) towed between 5 and 100 m above the sediment surface at abyssal depths in the NE. Atlantic have taken some excellent specimens of *P. diaphana* (Billett *et al.*, in press). Barnes *et al.* (1976) noted that the distribution of *P. diaphana* could be patchy. Although only one specimen was taken in SWT 15, another trawl on the Porcupine Abyssal Plain at 4510 m took 339 specimens (Billett *et al.*, in press). *P. diaphana* was the most abundant holothurian taken below 4000 m in the Bay of Biscay during the BIOGAS cruises (Sibuet, 1977).

The feeding activities of this species were observed by Barnes *et al.* (1976). They concluded that *P. diaphana* survives on a low-energy budget, the sedimentary material in the gut containing very little organic matter.

**REPRODUCTION.** The sexes are separate. Maximum egg size is *c.* 350  $\mu\text{m}$ , as in *P. azorica*, indicating that some form of 'abbreviated' early development may occur. Unspawned eggs appear to undergo phagocytic breakdown, again as with *P. azorica* (Tyler *et al.*, in press).

*Kolga hyalina* Danielssen & Koren, 1879

See: Hansen, 1975: 170–171, fig. 123; Billett & Hansen, 1982: 804–806, fig. 2.

SAMPLE. ES 172(15). [2910 m]

**DISTRIBUTION.** Arctic, North Atlantic, Antarctic, Pacific off Japan. Probably cosmopolitan, its patchy geographic distribution due, in part, to its unusual life-history (Billett & Hansen, 1982); 1510–4850 m.

**REMARKS.** Although fairly abundant in the one sample taken in the southern Rockall Trough in May 1980, *K. hyalina* was absent from all other samples at that station, including two taken in the same year. All the specimens were small and of a similar size (4–5 mm). Billett & Hansen (1982) found that *K. hyalina* exhibited characteristics typical of r-selected, or physically controlled, fauna (Sanders, 1979), which resulted in the periodic occurrence of a large number of juveniles in localised areas. Owing to predation the population may not persist for long. *K. hyalina* forms dense aggregations which may be caused by the patchy distribution of detrital material seen to collect on the sediment surface at certain times of the year (Billett *et al.*, 1983). *K. hyalina* is bioluminescent, emitting a bright blue light (Herring, 1974).

**REPRODUCTION.** *K. hyalina* reaches maturity at a very early age. The smallest specimens sampled (3 mm) have developing gonads (Billett & Hansen, 1982). The largest egg size is 180  $\mu\text{m}$  indicating indirect development.

Order **APODIDA**  
Family **SYNAPTIDAE**

*Labidoplax southwardorum* Gage, 1985

See: Gage, 1985: 255–261, figs 1, 3: A, D–F

SAMPLES. ES 20(1), ES 27(9), ES 28(1), SBC 48(1), ES 56(9), ES 57(3), SBC 58(2), ES 59(7), SBC 61(1), SBC

63(?2), SBC 67(1), ES 99(1), ES 105(2), ES 111(4), ES 118(2), ES 129(7, ?3), ES 135(1, ?1) ES 137(23), ES 140(?1), ES 143(4), ES 147(11), ES 152(2), ES 164(7), ES 169(8), ES 172(2), SBC 174(?1), ES 176(22), ES 180(9), ES 184(13), ES 190(3). [c. 1000–292 m]

**DISTRIBUTION.** This species is apparently widely distributed in the sediments of the Rockall Trough.

**REMARKS.** This is a small-sized species possessing eleven tentacles and body-wall deposits consisting of anchor-plates and anchors typical of the genus *Labidoplax*. However, the anchor plates are not only larger than those known from other species of this genus, which in any case is previously unknown in the deep sea, but also are unusual in being somewhat greater in length than the corresponding anchors, the size ranges being 129–207 and 110–188 µm, respectively. As preserved, they overlap making the skin stiff and inflexible; however, this must have resulted from contraction of the body, otherwise it would not be possible for these deposits to function normally (see Mortensen, 1927). In number of tentacles and absence of accessory deposits, *L. southwardorum* resembles the coastal *Labidoplax buski* (McIntosh, 1866). The latter is known from the coast of Norway to the Mediterranean, and off the Carolinas in the western Atlantic, to 550 m depth. However, although its anchors are similar in size, the anchor plates are distinctly smaller.

None of the specimens was complete, most consisting only of the oral ring, measuring 0.9–1.6 mm diameter. This probably resulted from autotomy on disturbing the animal rather than from the cutting edge of epibenthic sledge, because intact animals were not recovered from the box-core samples.

The tentacles bear two pairs of lateral digits that, although contracted in the present specimens are probably extended in life serving to gather material from the sediment surface. The gut in the few body fragments usually appeared distended with contained sediment.

#### *Labidoplax similimedia* Gage, 1984

See: Gage, 1985: 255–261, figs 2, 3, B–D.

**SAMPLES.** ES 34(1), ES 147(1), ES 169(2), ES 172(1), ES 176(1), ES 190(2), ES 200(1), ES 204(2). [2220–2925 m]

**DISTRIBUTION.** Hebridean slope, central and southern areas of the Rockall Trough.

**REMARKS.** This small-sized species occurred in samples together with *Labidoplax southwardorum*. *L. similimedia* is distinguishable by both the considerably smaller size of the anchor-plates and anchors in the body wall, and the presence of rod deposits with branched ends within the tentacles. These latter deposits appear similar to those of *Labidoplax media* Östergren, 1905 (see also Gotto & Gotto, 1972). *L. media* is a coastal species known only from scattered records off Norway, the British Isles and the Mediterranean down to 95 m depth. However, the present species possesses only 11 tentacles rather than the 12 of *L. media*. All specimens were incomplete, consisting either of the anterior end of the body with the oral ring, 0.8–1.4 mm in diameter, or a body fragment.

As with *L. southwardorum*, this may be the result of autotomy when disturbing the animal, while the crowding of the deposits in the body wall again suggests this is an artefact reflecting contraction of the body-wall musculature.

#### *Protankyra brychia* (Verrill, 1885)

See: Madsen, 1953: 151–173, fig. 1.

**SAMPLES.** ES 32(1), ES 56(1), ES 152(1), ES 164(1), ES 169(1), ES 172(2), ES 180(1), ES 185(2), SBC 188(1), ES 207(2). [2871–2925 m]

**DISTRIBUTION.** Probably throughout the deep Atlantic between 47°N to 16°S, where it has been recorded as either *brychia* or *abyssicola* Théel, 1886a, the two names being synonymised by Deichmann (1940); 1688–4990 m. Although Clark (1920) indicates that *P. pacifica* (Ludwig,

1894), obtained by the *Albatross* from off Panama, is conspecific with *P. abyssicola*, Deichmann (1940) and Madsen (1953) consider *pacifica* should be maintained as a distinct species.

Only two specimens were intact, one measuring 32 mm and the other 38 mm long. Another was in two halves, together measuring 26 mm. The remainder were incomplete, lacking either the anterior or posterior end. Most were strongly contracted but otherwise in good condition. Hence, the body lengths measured probably do not reflect their size in life. Colour ranged from a yellow-orange, particularly evident in the tentacles, to a greyish-white colour. The body wall was wrinkled, probably as a result of contraction of the powerful radial and longitudinal musculature.

**REMARKS.** Examination of the skin of several small specimens in the present collection revealed the presence of not only the anchors and plates typical of this species, though slightly smaller than usual, but also curved rods and auricularia-like wheels. The curved rods were of widely varying shape, sometimes toothed along their length and always more or less branched at the ends. They were scattered in the body wall, and particularly abundant in the tentacles. The presence of wheels is surprising in postlarval stages, although such deposits have long been known to occur in synaptid auricularia larvae (Semon, 1888; Chun, 1896). They measured 84–99  $\mu\text{m}$  in diameter with 12–18 spokes radiating from a wide hub measuring 32–40% of wheel diameter and possessing a conical protruberance in the centre. Around the rim were *c.* 100 minute inwardly pointing teeth. Both in the latter respect, and in their size and other characteristics, these wheels appear closely similar to those described by Pawson (1971) in the giant pelagic larva, 'Auricularia nudibranchiata' from deep water off New Zealand.

On the smallest specimen examined, 4.5 mm long, but lacking the posterior end, the plate apertures were always untoothed but otherwise resembled the developing plates, also untoothed, on larger specimens. The size and degree of development of the anchors and plates seemed to be related to body size, those of the largest specimens examined (37 mm long, but severely contracted) up to 500  $\mu\text{m}$  and 460  $\mu\text{m}$  in length, respectively. On the smallest specimen examined (measuring 4.5 mm) anchors measured up to 376  $\mu\text{m}$  and plates up to 285  $\mu\text{m}$ , while on specimens of intermediate size anchors and plates ranged between these two sets of values. In addition, in the tentacles and body wall of the largest specimen the curved rods were reduced to single unbranched rods or smooth oval particles. A similar relationship between body size of the anchors and anchor-plates was noted in the affiliated species *Rynkatorpa hickmani* described by Rowe & Pawson (1967). In view of this evidently body-size-related variability in the deposits, a revision of *Protankyra* and related taxa is necessary together with checking of other described species from the deep sea. Moreover, the presence of closely similar wheels on the very large larva 'Auricularia nudibranchiata', specimens of which have been obtained up to 15 mm long (Ohshima, 1911) and for which the adult is unknown, suggests a possible link with the genus *Protankyra*.

**REPRODUCTION.** The long, slightly branched gonads of the largest specimen, length 37 mm, from ES 185 and that from ES 32, length 26 mm, were removed and each found to contain a number of large, roughly globular, vitellogenic oocytes. Measurements of these gave a unimodal distribution of size frequencies peaking at about 100  $\mu\text{m}$  diameter. The largest oocytes found were ovoid or sausage-shaped and measured up to around 200  $\mu\text{m}$  in length.

### Family MYRIOTROCHIDAE

#### *Myriotrochus bathybius* H. L. Clark, 1920

*See:* H. L. Clark, 1920: 126–127, pl. 4, fig. 3; Gage & Billett, in press.

**SAMPLES.** ES 6(1), ES 27(1), ES 56(3), SBC 68(1), ES 118(1), ES 129(2), ES 137(1), ES 147(3), ES 152(1), ES 164(2), ES 169(2), ES 172(2), ES 180(2), ES 184(1), SBC 188(1), ES 190(2), ES 204(1), ES 207(3). [c. 1800–2925 m]

**DISTRIBUTION.** The only published records are from the type locality in the eastern equatorial Pacific, 3666 m, and NE. Pacific off Oregon although *M. bathybius* was also taken by the

*Galathea* in the Indian and South Atlantic Oceans (Dr Bent Hansen, Copenhagen, personal communication) and by the *Discovery* at 3680–4104 m depth in the Porcupine Seabight. An unidentified *Myriotrochus* sp. recorded by Cherbonnier (1969) from 485 m off NW. Spain is likely to be a related species (see Gage & Billett, in press).

REMARKS. Gage & Billett (in press) record this species for the first time in the North Atlantic, occurring both in unpublished *Discovery* trawlings from the Porcupine Seabight at 3680–4104 m depth, 6 specimens, and in the present samples from Rockall. The fairly wide range in variation seen in measurements made on the wheels of the present Rockall specimens was found by Gage & Billett to encompass both that of the two specimens described by Clark (1920) and the *Discovery* specimens from the Porcupine Seabight.

A 2.9 mm long specimen of a probably parasitic species of the gastropod family Eulimidae was found lying within the gullet of one large *M. bathybius* from Rockall.

REPRODUCTION. Maximum size of oocytes in the paired, branched female gonads was 160  $\mu\text{m}$  (Gage & Billett, in press). On the tentacles and oral disc of three of the Rockall specimens and one of the two *Discovery* specimens from the Porcupine Seabight were found numerous, small, four- or five-tentacled forms with an attaching disc. They were all approximately the same size and it is possible that these are brooded larvae at the Pentactula stage.

### *Myriotrochus giganteus* H. L. Clark, 1920

See: Clark, 1920: 127–128, pl. 4, fig. 4; Belyaev & Mironov, 1981: 179–170, fig. 4, tables 4, 5 (as *M. macquoriensis* [sic]).

SAMPLES. ES 137(1), ES 164(2), ES 207(1). [2898–2925 m]

DISTRIBUTION. The only published records are from the type locality in the eastern equatorial Pacific, 3666 m and from the NE. Pacific off Oregon, 3300–3800 m. However, Gage & Billett (in press) synonymise *Myriotrochus* sp. ex gr. *macquoriensis-giganteus* Belyaev & Mironov, 1982 from the eastern equatorial Pacific at 3370–3400 m, with *M. giganteus*. It seems probable that *M. giganteus* has a cosmopolitan distribution at abyssal depths in the world ocean.

REMARKS. The only complete specimen was that obtained from ES 207. It measured 27.5 mm in length with a slightly inflated anterior section of the body. The calcareous ring measured 3 mm in diameter, while that of the other, incomplete, specimens ranged from 2.8 to 4 mm. A detailed description of the present specimens, including details of the body wall deposits and the morphology of the plates of the calcareous ring, is given by Gage & Billett (in press), who also discuss and justify the synonymy with the nominal species described by Belyaev & Mironov (1982).

REPRODUCTION. A pair of female, tubular-shaped gonads was found in the specimen from ES 207. The few, irregular-shaped vitellogenic eggs that could be seen inside, maximum diameter 211  $\times$  169  $\mu\text{m}$ , suggests that some form of indirect early development occurs.

### *Myriotrochus* sp.

See: Gage & Billett (in press).

SAMPLES. ES 34(1), ES 197(1), ES 200(2), AT 221(9), [1605–2515 m]

DISTRIBUTION. This species was not found in the many hauls from depths greater than 2515 m in the Rockall Trough.

REMARKS. None of the specimens obtained were complete; although in one only the tip of the posterior end appeared to be missing. The body length of this specimen was 18.7 mm with a maximum width of 3.4 mm just behind the oral ring. The anterior third of the body was rough-surfaced with numerous irregular short processes whilst the posterior part was smooth. The body lacked pigmentation, and possessed 12 tentacles, now retracted, each possessing two pairs of short rounded lobes. The wheels were of typical myriotrochid form; details of various wheel

measurements are given in Gage & Billett (in press) together with a description of the morphology of the plates of the calcareous ring.

*Prototrochus zenkevitchi* (Belyaev, 1970) subsp.

See: Gage & Billett (in press).

SAMPLES. ES 6(2), ES 10(1), ES 15(2), ES 20(11), ES 34(?1, 3), ES 57(1), SBC 64(2), SBC 67(1), ES 105(2), ES 129(4), ES 135(1), ES 137(1), ES 147(1), SBC 155(7), ES 169(1), ES 172(3), ES 176(12), ES 190(1), ES 197(30), ES 200(8), ES 207(2). [c. 1000–2921 m]

DISTRIBUTION. Widely distributed in the Rockall Trough, and with a wide bathymetric range in soft mud and ooze.

REMARKS. This small species is evidently fragile as most specimens consist of the anterior end only. From the body length of the few intact specimens, Gage & Billett (in press) estimate the likely maximum size as c. 10 mm. The average inferred length was a little less than 5 mm. In the body wall there are numerous wheel-like deposits typical in form to those of the Myriotrochidae. However, there are 10 tentacles, rather than 12 as defined for the genus *Myriotrochus* by Belyaev & Mironov (1982), so the taxon must be placed in the recently established genus *Prototrochus* Belyaev & Mironov, 1982 along with other previously described species with 10 tentacles. Gage & Billett show the present material to have close affinity to *P. zenkevitchi* Belyaev, 1970, described from material trawled from various trenches in the NW. Pacific. A degree of variation was evident between samples from different trenches in terms of measurements of the typical myriotrochid wheels present, while a separate subspecies was erected for one population in which wheels were very few or absent. Later a further subspecies, *M. zenkevitchi atlanticus* Belyaev & Mironov, 1977 was described from the Romanche Trench off Senegal. The generally small body size of the present material might be interpreted as reflecting numerical dominance by juveniles in the population. However, no size-related correlations in wheel parameters were apparent from extensive measurements, and Gage & Billett therefore concluded that the differences evident in wheel parameters, compared to those for the previously described subspecies of *Prototrochus zenkevitchi*, justifies taxonomic distinction of the Rockall material.

In view of the sediment-filled gut that distended the body of complete specimens, it seems that this small species probably feeds on the bottom deposit.

**Myriotrochidae gen. et sp.**

See: Gage & Billett (in press).

SAMPLES. ES 56(1), ES 57(1), ES 105(2), ES 135(2), ES 143(1), ES 152(1), ES 169(1), ES 172(1), ES 180(1), ES 197(1), ES 204(1), ES 207(1). [1690–2921 m]

DISTRIBUTION. Probably with a distribution in Rockall similar to that of *Prototrochus zenkevitchi*.

REMARKS. All but one of the specimens are minute, varying in length from 1.3 to 2.3 mm in length. The body wall is densely covered with curved, pointed rods in addition to some scattered, small wheels (35–60 µm diameter) of the typical myriotrochid design. There are 10 tentacles, each with two, possibly more, pairs of lobes and with curved rods at their base. The short, spiny body has a pointed posterior end reminiscent of aplacophoran molluscs, and Gage & Billett (in press) speculate that these holothurians have a similar mode of life in the superficial layer of the sediment.

*Prototrochus* sp. aff. *P. minutus* (Östergren, 1905)

See: Gage & Billett (in press).

SAMPLE. SBC 155(1). [1330 m]

DISTRIBUTION. Known only from the N. Bay of Biscay.

REMARKS. This specimen, 2.4 mm long, was collected from the Whittard Canyon, northern Bay of Biscay. It resembles the previous specimens in having 10 tentacles of the same form, and has similar wheel deposits in the body wall. However, although rod-shaped deposits are found around the base of the tentacles, they are absent from the body wall. The specimen shows affinity to *Prototrochus minutus* (Östergren, 1905), a species known only from the Sea of Japan



(Östergren, 1905; Belyaev & Mironov, 1982), which has similar wheel and rod-shaped deposits, the latter only around the bases of the tentacles. The specimens also shows similarities to the Rockall individuals of *Prototrochus zenkevitchi*, particularly with reference to the structure of the wheels, but differs and in the occurrence of rods at the tentacle base at this size (1–3 mm). Both have a similar bathymetric and geographic distribution in this area.

Order **MOLPADIIDA**  
Family **MOLPADIIDAE**

*Cherbonniera utriculus* Sibuet, 1974

*See*: Sibuet, 1974: 1443–1445, pl. 1.

**SAMPLES.** ES 2(107), ES 6(1550), ES 8(85), ES 10(4), ES 27(130), ES 28(3), ES 34(1), ES 55(194), ES 56(119), ES 57(17), SBC 58(1), ES 59(49), ES 111(65), ES 118(34), AT 119(33), ES 129(91), ES 135(49), ES 137(156), ES 140(114), ES 143(19), ES 147(122), SBC 150(1), ES 164(180), ES 169(87), ES 172(114), ES 180(275), ES 185(23), SBC 188(1), ES 190(7), ES 204(78), SBC 205(juvenile 1), ES 207(2). [2515–2925 m]

**DISTRIBUTION.** Previously known only from the Bay of Biscay; 2039–4251 m, on soft ooze.

**REMARKS.** The evident abundance of this species in the fine-meshed trawl hauls from depths greater than *c.* 2500 m indicates *Cherbonniera utriculus* may be found to be a common constituent of the deep-sea fauna in the NE. Atlantic. Because of its small size, it has probably either been overlooked or lost through the coarse meshes of the trawls used in previous deep-sea investigations. The sediment-filled gut suggests a deposit-feeding mode of life. The present records indicate that *C. utriculus* may have a patchy distribution.

**REPRODUCTION.** Our observations suggest the sexes to be separate, the gonads of females being short-branched tubules that are packed with eggs, measuring up to 200 µm in diameter (Tyler *et al.*, in press).

*Molpadia blakei* (Théel, 1886)

*See*: Heding, 1935: 72–76, pl. 4, figs 13, 14, pl. 5, figs 20, 21 (as *Paratrochostoma spiniferum*); Deichmann, 1940: 224–225, pl. 38, figs 6–8.

**SAMPLES.** ES 143(1), AT 144(1), SBC 150(?[juvenile] 1), AT 153(1), AT 167(1), AT 171(1), AT 175(1), ES 176(4), AT 177(2), AT 181(1), ES 184(1), ES 185(3), AT 191(3), AT 195(3), AT 198(1), AT 201(1), ES 202(1), ES 207(1), AT 219(4). [1991–2916 m]

**DISTRIBUTION.** North Atlantic, 1747–5270 m. *M. blakei* has been found to be particularly abundant in the Bay of Biscay at 3100 and 4100 m (Sibuet, 1977). Its apparent abundance at shallower depths in the Rockall Trough is probably due to sampling bias.

**REMARKS.** A thorough description of this species was given by Heding (1935) under the name *Paratrochostoma spiniferum*, who also noted its similarity to *Trochostoma blakei*. Deichmann (1940) during a revision of the Molpadiida synonymised the two names under the genus *Molpadia*.

Analysis of the gut content of this infaunal holothurian shows a close correlation to the surrounding sediment (Khripounoff and Sibuet, 1980).

*Molpadia borealis* Sars, 1858

*See*: Heding, 1935: 60–61, fig. 16, pl. 5, figs 6–7, pl. 8, fig. 3 (as *Trochostoma boreale*); 52–58, figs 13–14, pl. 4, figs 1–6, pl. 5, figs 1–5, pl. 8, fig. 1 (as *Trochostoma thomsonii*); Deichmann, 1936: 455–458, figs 4–6.

**SAMPLE.** AT 107A [*c.* 2000 m]

**DISTRIBUTION.** Arctic and the northernmost parts of the North Atlantic *c.* 225–1600 m. The present specimen represents the deepest and the most southerly record of *M. borealis*, which is usually distributed north of the Wyville-Thomson Ridge between 600 m and 1000 m where the water temperature is about 0.5°C. Its occurrence south of the Ridge but in deeper water supports Ludwig & Heding's (1935) proposal that the water temperature is important in limiting the distribution of this species.

REMARKS. The taxonomic characters of the Molpadiidae are so variable that it is not possible to describe satisfactorily a species without a full size distribution. The changes that occur with growth, even in the shape of spicules, have led in the past to the proliferation of many generic and specific names. The number of species was reduced to 10 within the single genus *Molpadia* by Deichmann (1940) for specimens taken in the Atlantic Ocean. Of the five nominal species originally described for the Arctic Ocean, Deichmann (1936) retained just two: *Molpadia borealis* (with synonyms *Ankyroderma jeffreysi* Danielssen & Koren, 1879, *Ankyroderma affine* Danielssen & Koren, 1872 and *Trochostoma thomsonii* Danielssen & Koren, 1878) and *Molpadia arctica* (Marenzeller, 1877).

The present specimen is in good condition and is 85 mm long, about half the size of a fully grown individual.

### Discussion

In part 1 of the 'Echinoderms of the Rockall Trough' (Gage *et al.*, 1983) certain features of the bathymetric distribution of the sea lily, sea star, and brittle star species could be related to both the rather circumscribed area of the Rockall Trough and to its complex hydrography. The bathymetric range of adult specimens of many species was found to be narrower than the known worldwide bathymetric range. The geographic and bathymetric distributions of juveniles and post-larvae of some of the relatively abundant species were considerably greater than for the adult specimens. In addition, it was suggested that the higher species richness evident in the relatively small numbers of samples taken from the western side of the Rockall Trough, compared to the eastern side where sampling effort was heaviest, may be related to the conditions in this area which favour microphagous suspension feeders.

Some species of echinoids and holothurians show a similar restriction in their bathymetric distribution in the Rockall Trough in comparison to their known global bathymetric range, notably *Cidaris cidaris*, *Calveriosoma hystrix*, *Echinus alexandri*, *Spatangus raschi* and *Benthogone rosea*. In general the shallowest record of most species occurring in the Rockall Trough was considerably deeper than the shallowest depth those species are known to be able to attain. This may be the effect of temperature. Several species are known to occur at very shallow depths in the cold water at high latitudes, for example *Stichopus tremulus*. The progressive submergence of cold, deep ocean water towards low latitudes (Wüst, 1936) may lead to the progressive depression of the upper bathymetric limit of benthic animals. One species, *Molpadia borealis*, thought to be limited between 600 and 1000 m north of the Wyville Thomson Ridge by the 0.5° isotherm, was found at a much greater depth, i.e. in colder water, south of the ridge. Many species appear to have a lower bathymetric limit at about 2950 m, but this is merely due to the small area of the Rockall Trough deeper than 3000 m and to the lack of samples from this area.

The small number of records from the relatively few western stations compared to the numerous records emanating from the eastern side of the Rockall Trough would appear to reflect the greater sampling effort in the east. This is in contrast to the pattern found for the Asteroidea and Ophiuroidea, which included several suspension-feeding species. Echinoids are unknown as microphages, being either predators, or scavengers of material associated with the substratum, or deposit feeders like the majority of holothurians of which a few microphagous feeders are known. There were only two holothurian species from the present sampling that are probably suspension feeders: *Psolus pourtalesii* and *P. squamatus*; the latter occurred only on the Anton Dohrn Seamount at 713 m depth, whilst *P. pourtalesii* occurred only in a single haul from the Feni Ridge in 2190 m depth.

The other feature of the distribution of sea stars and brittle stars in Rockall that was noted by Gage *et al.* (1983), was of a broader postlarval/juvenile bathymetric range compared to that of adults. This was evident only amongst certain echinoids. These included the species of the genus *Echinus* and *Hemiaster expergitus*. Studies by Tyler & Gage (1984a) indicate that three *Echinus* species recorded from deep water in the Trough have both seasonal periodicity in breeding and probable planktotrophic development. Unfortunately, it has not proved possible to separate to

species records of postlarvae belonging to *Echinus*. Therefore we cannot say for individual species whether settlement occurs over a greater area or wider range in depth than that of the breeding population. However, since the maximum depth (2910 m) for records of *Echinus* postlarvae well exceeded the bathymetric limits of the deepest living species (*E. affinis* and *E. alexandri*), a dispersion of larvae beyond the limits of the adult population seems likely for all three species.

The wide juvenile limits for the burrowing species *Hemister experegitus*, however, may be less significant. The discovery of a large specimen deeply burrowed in a box core indicates that surface skimming gear such as fine-meshed trawls and sled samplers will probably miss the more deeply burrowed adults whilst catching younger specimens that are able to burrow only superficially within the sediment.

Hansen (1975) suggests that the distributions of some bathyal and abyssal holothurian species are related to deep ocean currents. The egg size of most species is large, in some cases exceeding 1000 µm in diameter, reflecting their ability to subsist and develop independently of planktonic food for long periods and ensuring wide dispersal by currents. The noticeable poverty in holothurian records, particularly of elasipods on the western side of the Rockall Trough, may be related to the southwards-flowing current regime on the Feni Ridge, which is thought to mark the course of cold Norwegian Sea water overflowing into the North Atlantic via the Wyville Thomson Ridge (Jones *et al.*, 1970; Ellett & Roberts, 1973; Roberts, 1975). By contrast, in the east the bottom and slope water is more likely to have a southerly origin (Lonsdale & Hollister, 1979).

### Summary

Eighteen species of sea urchin and thirty-three species of sea cucumber are identified from recent sampling conducted by the Scottish Marine Biological Association, chiefly from RRS *Challenger*, in the deep-sea areas lying to the west of the British Isles. The following species have not previously been recorded from the British seas (taken as including the northern Bay of Biscay area), although in some cases their presence there was predicted by Mortensen (1927).

#### Echinoidea

#### Holothurioidea

*Aeropsis rostrata*  
*Psolus pourtalesii*  
*Abyssocucumis abyssorum*  
*Benthothuria funebris*  
*Labidoplax southwardorum*  
*Labidoplax similimedia*  
*Myriotrochus bathybius*  
*Myriotrochus giganteus*  
*Myriotrochus* sp.  
*Prototrochus zenkevitchi* subsp.  
*Prototrochus ? minutus*  
*Molpadia borealis*

#### UPPER LIMIT

#### LOWER LIMIT

#### Echinoidea

<i>Hygrosoma petersii</i>		2870–2965
<i>Sperosoma grimaldii</i>		2300–2910
<i>Echinus affinis</i>		2230–2450
<i>Aeropsis rostrata</i>	2550–1200[?1000]	
<i>Echinosigra phiale</i>		2377–2912

#### Holothurioidea

<i>Abyssocucumis abyssorum</i>		4636–4810
<i>Benthothuria funebris</i>		2700–2996
<i>Mesothuria cathedralis</i>		2480–2540
<i>Laetmogone violacea</i>		1804–[3000]
<i>Molpadia borealis</i>		1600–2000

In this list the depths given are the minimum possible extensions of the previously known bathymetric limits. The figure in square brackets results from a record of specimens that may have been carried into deeper water by some down-slope process.

Postlarvae that could be identified only as belonging to the genus *Echinus* were collected from depths considerably in excess of the maximum depth recorded for the adults of the three species recorded from deep water. Although this is indicative of a wide bathymetric distribution of postlarvae, it remains unknown whether this applies to all three species found as breeding populations. Except for pourtalesiids, young stages of other echinoids, and of holothurian species recorded were but rarely, or never, found. It seems likely that this is related to both fecundity and mode of larval development. Whereas the *Echinus* species show the high fecundity associated with probable planktotrophy, the pourtalesiids displayed a lower fecundity and probable lecithotrophic mode of development. In the echinothuriids, and probably most of the holothurians, a lower fecundity is evident as a result of the often very large egg size. This may reflect an ability to subsist and develop independently of planktonic food for long periods, thus ensuring wide dispersal by currents.

In general terms, records of adults of the most abundant species are, like those of asteroids and ophiuroids, clustered well within the vertical range recorded over their, often circumoceanic, distribution.

### Relationships needing further investigation

In the course of examination of the material we have found the following taxonomic relationships need further investigation as possible synonymies:

- Benthothuria funebris* R. Perrier, 1902 and  
*B. valdiviae* Heding, 1940;
- Paelopatides gigantea* (Verrill, 1884) and  
*P. grisea* R. Perrier, 1902.

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